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Acidophilous grasslands in the Locarnese region (Southern Switzerland): description and classification of main plant communities

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Abstract

This paper presents a phytosociological study of dry and mesophilous meadows and pastures in the Locarnese region (Insubria - Southern Switzerland). Seventy-one vegetation relevés were analysed using both hierarchical classification and nonmetric multidimensional scaling (NMDS) ordination. Seven main clusters were identified and described as follows: (i) xerophytic grasslands on sandy soil dominated by *Koeleria macrantha*; (ii) mesophilous meadows with *Arrhenatherum elatius* and *Centaurea transalpina*; (iii) semi-dry meadows with *Chrysopogon gryllus*; (iv) semi-dry grasslands with *Carex fritschii* and *Thalictrum minus*; (v) nutrient-poor *Phyteuma betonicifolium-Festuca nigrescens* montane zone grasslands; *Nardus stricta* grasslands dominated by (vi) *Festuca paniculata* or (vii) *Carex pilulifera*. From a phytosociological point of view, a new association named *Phyteumo betonicifolii-Festucetum nigrescentis*, classified into the *Nardo strictae-Agrostion tenuis* alliance was proposed. In addition, we confirmed the presence of the *Holco-Chrysopogonetum grylli* association, within the *Bromion erecti*, which up to now was provisional only.

Keywords

dry meadows, *Festuco-Brometea*, Insubria, *Molinio-Arrhenatheretea*, *Nardetea strictae*, phytosociology, pastures

Introduction

The Semi-natural temperate grasslands are plant communities that arose from the non-intensive use of pastures and meadows (Küster and Keenleyside 2009). European semi-dry grasslands are among the most important hotspots of vascular plant diversity (Wilson et al. 2012). Grasslands are a prominent feature in present-day landscapes, but both the intensification of management practices and land abandonment during the past decades have resulted in a widespread loss of traditional grasslands, their homogenization and a concomitant loss of biodiversity (Poschlod et al. 2009; Prévosto et al. 2011).

The first study on Swiss grassland vegetation was published in 1887 by Stebler & Schröter. Since then, studies have been performed in various regions of Switzerland (Studer-Ehrensberger 1995). A synthetic overview of mesophilous species-rich meadows is provided by Studer-Ehrensberger (2000). Literature on Swiss meadows has been reviewed for the classes *Caricetea curvuleae*, *Elyno-Seslerietea* and *Molinio-Arrhenatheretea* as part of the classification system of Swiss plant associations PhytoSuisse (Prunier et al. 2014, 2019). The elaboration of the classification of mesophilous meadows and pastures is primarily based on the relevant national literature (Koch 1926; Marschall 1947, 1951; Berset 1965; Dietl 1972, 1983) as well as for dry meadows (Zoller 1954; Braun-Blanquet 1961, 1976; Meyer 1976; Delarze 1986; Eggenberg et al. 2001).

In Switzerland, so far, only few studies have dealt with the flora and vegetation of the Insubrian region South of

the Alps (Schröter 1936; Oberdorfer 1964; Reisigl 1996). In particular, *Chrysopogon gryllus* meadows (Koch 1943; Meyer 1976, 1977) and grasslands with *Festuca paniculata* (Vittoz et al. 2005) were considered. An overview of the dry grasslands of the lowlands in the whole Insubrian range was also provided (Studer-Ehrensberger 1993).

For the Canton of Ticino, early comprehensive studies were performed by Jäggli (1908) and Bär (1914). Further studies were carried out by the "Prati magri ticinesi" confederation project at the beginning of the 1990s (Antognoli 1995; Häfelfinger 1996; Pestalozzi 1990). However, the phytosociological classification of the siliceous communities of the Locarnese region has been neglected so far (but see Bär 1914; Pestalozzi 1990). Current Swiss reference literature (Delarze et al. 2015; Prunier et al. 2019) is accurate for the grassland communities of the northern Alps, but is incomplete with regard to those in the Southern Alps, in particular the meadows and pastures on siliceous soils. Nutrient-poor montane zone grasslands with *Festuca rubra* and *Agrostis capillaris* have already been described (Thomet et al. 1989; Pestalozzi 1990; Häfelfinger 1996; Studer-Ehrensberger 2000; Dietl in Klötzli et al. 2010) but were not integrated in the current classification systems in Switzerland (Delarze et al. 2015; Prunier et al. 2019). The same holds true for the xerophytic grasslands on sandy soils (Studer-Ehrensberger 1993).

This paper proposes a phytosociological overview of the siliceous meadows and pastures in the foothills and montane zone of the Locarnese region (200–1,500 m a.s.l.). The aims of the study were to describe and classify grassland communities occurring in the area. The study is expected to shed new light on the phytosociological classification of these grasslands and to test the occurrence of new plant associations specific to the Insubrian region.

Materials and methods

Study area

The study area covered approximately 230 km^2 in the Canton of Ticino (Fig. 1), including Valle Onsernone, Valle Vergeletto, the Swiss lakeside of Lago Maggiore, Centovalli, the Terre di Pedemonte, and part of the Valle Maggia. The region is characterized by a complex dendritic drainage system and steep gradients typical of mountain regions, which contributes to high landscape and vegetation diversity in a relatively small area (Spinedi and Isotta 2004). The altitude ranges from 200 m a.s.l. (Losone) to 2,187 m a.s.l. (Gridone). Due to the gradual abandonment of agriculture starting from the 1950s, agricultural surfaces now account for less than 5% of the studied area (Gianoni et al. 2015).

From a biogeographical point of view, the Locarnese region is particularly interesting due to its geological and climatic features. These characteristics result in a unique floristic diversity that was early recognized (Schröter 1936; Oberdorfer 1964).

From a geological point of view, the Locarnese has a special position. The Insubric Line, a fault line between the European and African plates, passes across the Centovalli. It marks the boundary between the Central Alps and the Southern Alps and is the southern limit of Alpine metamorphism. A mylonite belt surrounds this line, with ultramafic, mafic and paragneisses to the South, and gneiss, metagranitoide and mica-slate to the North (Schmid et al. 1987).

The Insubrian climate (Fig. 2) is characterised by high annual precipitations (2,060 mm average in Mosogno). Winters are mild and relatively dry with an absence of

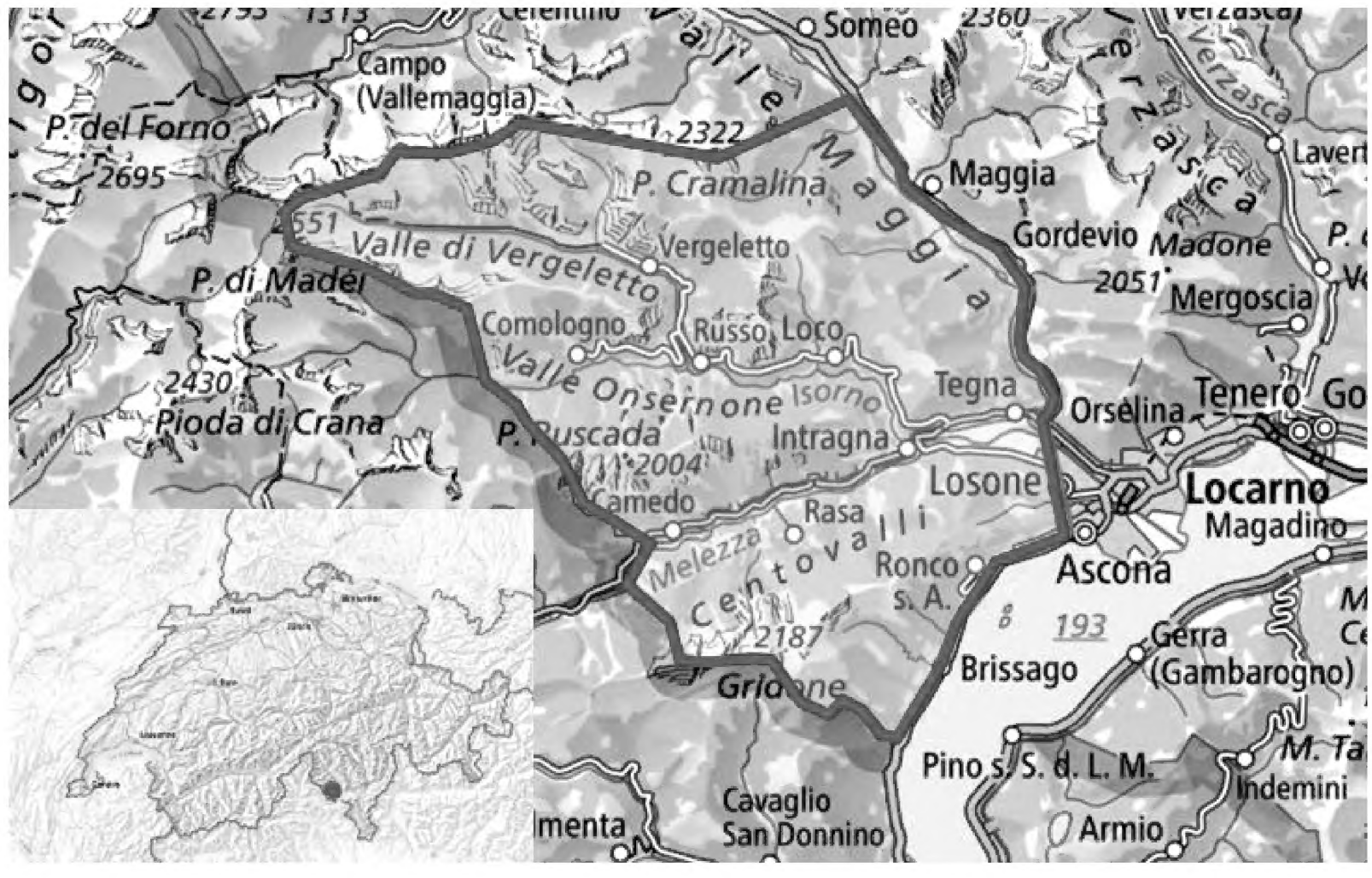

Figure 1. Study area in the Locarnese region, Ticino - Switzerland. Copyright: data swisstopo, https://map.geo.admin.ch/.

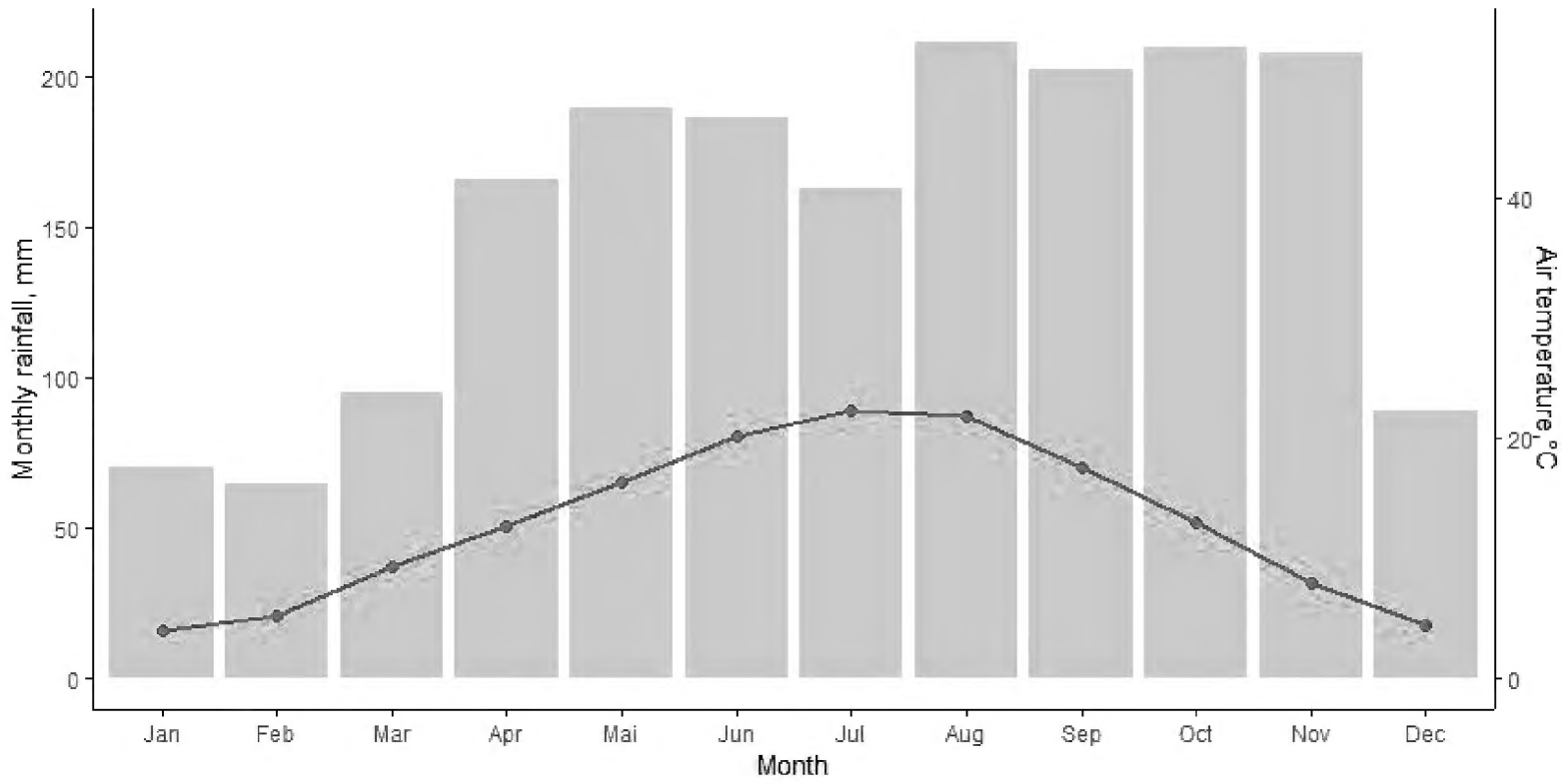

Figure 2. Thermo-pluviometric diagram for 1991–2020. Average monthly temperature and rainfall in Locarno/Monti, 366 m a.s.l. Data obtained from the Federal Office of Meteorology and Climatology MeteoSwiss (Ufficio federale di meteorologia e climatologia MeteoSvizzera 2022a, 2022b)

strong frost, summers are marked by recurrent violent showers, spring and fall seasons with heavy precipitations (Spinedi and Isotta 2004; Pautasso 2013; Ufficio federale di meteorologia e climatologia MeteoSvizzera 2022a, 2022b).

In the foothill zone, forests are composed by deciduous tree species. Forests dominated by *Castanea sativa* are the most abundant and account for 20% of the total forested area in Ticino (Dipartimento del territorio 2008). On siliceous soil, *Quercus* sp.-*Betula pendula* forests, belonging to the *Quercion-robori petraeae* alliance, is the potential natural vegetation. Above an altitude of 800 m a.s.l., the main forest types are characterised by *Fagus sylvatica* and *Abies alba* (Schmid 1939; Reisigl 1996). Mild winters and high mean annual rainfall favour the occurrence of subatlantic species, e.g. *Festuca filiformis*, *Cytisus scoparius* and *Teucrium scorodonia*. Submediterrean (e.g. *Chrysopogon gryllus*) and mountain plants (e.g. *Festuca paniculata*) also contributed to the local flora. Warm temperatures e summer drought favour also the occurrence of some steppic plant species from the East, like *Thesium linophyllum* or *Peucedanum oreoselinum* (Koch 1943).

Data collection and analysis

Seventy-one vegetation relevés were analyzed. This includes 70 surveys conducted during spring and summer of 2016 and 2017, as well as one survey from the national inventory of dry meadows and pastures (Eggenberg et al. 2001).

All relevés were performed using the Braun-Blanquet approach (Braun-Blanquet 1964). The plots were circular areas of 25 m^2. The 70 relevés were selected using a two-step procedure. First, grassland areas were identified by combining information from a 1:10,000 national map and photointerpretation of Swiss aerial images (2004–2006) (Swiss Confederation geographical information portal). Subsequently, the grasslands to be studied were selected along an elevation gradient from 200 to 1,500 m a.s.l., distributed in the whole area. In Valle Maggia only the floodplain was considered. Secondly, plots were selected following a preferential design (Cáceres et al. 2015). The plots were selected based on the following criteria: (i) minimal size of at least 1000 m^2; (ii) cover of abandonment indicator species *Molinia arundinacea* and *Pteridium aquilinum* < 30%; Location and date of each relevé are listed in Appendix 1. Plot with high cover values of *Molinia arundinacea* and *Pteridium aquilinum* were not considered as potentially involved in vegetation dynamics due to management abandonment, as these two species have been proved to become invasive during the first stages of mowing abandonment.

The species cover values were transformed into ordinal scale values according to van der Maarel (1979). The data were analysed by a multivariate approach using both hierarchical cluster analysis and unconstrained ordination methods. In order to minimize the influence of occasional species, only species with a frequency higher than 5% were considered. Different asymmetrical association measures (Chord, Hellinger, Bray-Curtis and Bray-Curtis log transformed indices) and aggregation methods (Single Linkage, Complete Linkage, Average Agglomerative Clustering and Ward's Minimum Variance Clustering) were combined as proposed by Legendre and Legendre (1998). The choice of the best combination of index and aggregation methods was performed using cophenetic correlation analysis (Legendre and Legendre 1998). This led to the selection of the Bray-Curtis index and the average agglomerative clustering Weighted Pair-Group Method (WPGMA) as best combination. Ordination was performed using nonmetric multidimensional scaling (NMDS), based on the Bray-Curtis similarity index with nine dimensions (20 tries, stress = 0.0579).

Indicators for the four main clusters and eight sub-clusters were determined using Indicator Species Analysis (ISA) as proposed by Dufrêne and Legendre (1997) to define the species fidelity values (Φ) and their significance. Fidelity values are statistics commonly used to determine the association between species and vegetation types, corresponding to the Pearson's phi coefficient of association. For the main groups (4 clusters), only significant species (p-value<0.05) with 10,000 permutations were considered. For the subset of the sub-groups, the p-value was increased (p-value<0.1). Species that occurred in at least 75 % of the relevés in the considered cluster were identified as "high frequency taxa". Species with cover/abundance indices ≥ 3 in at least one relevé in the cluster were considered to be "dominant taxa", as proposed by Di Pietro et al. (2017). Only species with a minimum frequency of 20% were listed in the phytosociological tables for the considered cluster. Sporadic species can be found in Appendix II.

Ecological characterization of the clusters was performed using weighted mean indicator values according to Landolt et al. (2010) for temperature (T), continentality (K), light (L), moisture (F), soil reaction (R), nutrients (N) and Humus (H).

Phytosociological attributions of species and floristic nomenclature were performed according to Flora Indicativa (Landolt et al. 2010), supplemented with Chytrý (2010). Some species were considered as aggregates, namely *Achillea millefolium*, *Alchemilla vulgaris*, *Hieracium murorum*, *Rubus fruticosus* and *Festuca ovina* aggr., except for *Festuca filiformis*. The syntaxonomic system for Europe, EuroVegChecklist was considered as reference (Mucina et al. 2016).

Calculation of mean Landolt's indicator values (Landolt et al. 2010) was performed using the VEGEDAZ vegetation database management programme (Küchler 2019). All mean relevés values were then plotted with box-plot representation for each sub-cluster, including also the elevation distribution. Soil pH was also qualitatively evaluated at each relevé site by a field colorimetric test applied to a small surficial soil sample collected on site. pH colorimetric method is based on the property of acid-base indicator dyes, which produce colour depending on the pH of the soil sample. Statistical analyses were carried out using R (R Core Team 2023). Similarity matrices, cluster analysis and ordination were performed using the vegan R package (Oksanen et al. 2019); Indicator Species Analysis was performed using the labdv R package (Roberts 2019).

Results and discussion

Overview

The results of the cluster analysis are shown in Figure 3. The analysis revealed two main groups: group "A" included grasslands on sandy soils of floodplains with *Koeleria macranta* (Φ 0.97; p-value<0.001) and *Artemisia camp-*

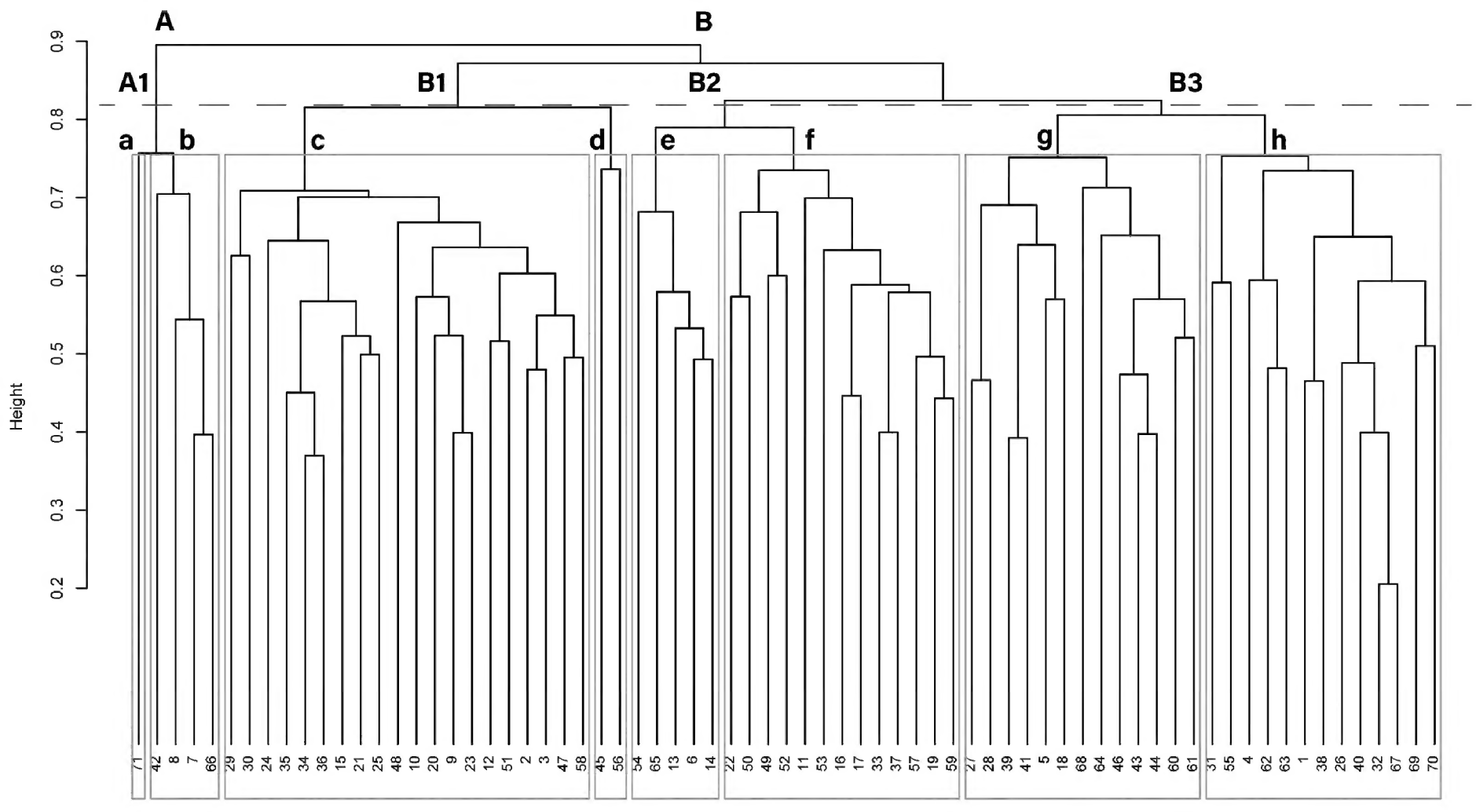

Figure 3. Dendrogramme of 71 phytosociological relevés (Bray-Curtis Index, WPGMA). A: Grasslands with *Koeleria macrantha*; B: Grasslands with *Festuca nigrescens*; A1: *Stipo-Poion xerophilae*; B1: *Arrhenatherion*; B2: *Bromion erecti*; B3: *Nardo-Agrostion*; a: *Poo bulbosae-Festucetum trachyphyllae*; b: *Poo bulbosae-Festucetum trachyphyllae*, mesophilic variant c: *Centaureo transalpinae-Arrhenatheretum*; d: outlier; e: *Holco-Chrysopogonetum grylli*; f: *Phyteumo-Mesobrometum*; g: *Phyteumo betonicifolii-Festucetum nigrescentis*; h: *Carici piluliferae-Nardetum strictae*.

estris (Φ 0.80; *p*-value<0.001); group "B" was composed by grasslands with the presence of *Festuca nigrescens* (Φ 0.70; *p*-value<0.01). In group "B" it was possible to distinguish three types of grasslands: group "B1" contained mesophilous meadows with a high frequency of *Arrhenatherum elatius* (Φ 0.59; *p*-value<0.001) and *Centaurea transalpina* (Φ 0.52; *p*-value<0.01); group "B2" contained semi-dry grasslands characterized by *Brachypodium rupestre* (Φ 0.55; *p*-value<0.001) and *Carex fritschii* (Φ 0.54; *p*-value<0.01); and group "B3" contained *Nardus stricta* grasslands (Φ 0.73; *p*-value<0.001). Based on the chosen indicators, the clusters were attributed to four alliances: *Stipo-Poion xerophilae* (A, five relevés), *Arrhenatherion elatioris* (B1, twenty-two relevés) *Bromion erecti* (eighteen relevés) and *Nardo-Agrostion* (B3; twenty-six relevés). Furthermore, six associations were determined *Poo bulbosae-Festucetum trachyphyllae* (a and b, five relevés), *Centaureo transalpinae-Arrhenatheretum* (c, twenty relevés), *Holco-Chrysopogonetum grylli* (e, five relevés), *Phyteumo-Mesobrometum*, (f, thirteen relevés), *Phyteumo betonicifolii-Festucetum nigrescentis*, (g, thirteen relevés) and *Carici piluliferae-Nardetum strictae* (h, thirteen relevés). One cluster, in the *Arrhenatherion* alliance, was considered to be an outlier (d, two relevés, see Appendix III): one relevé was dominated by *Festuca nigrescens* with a cover value of 5, the second one was a very rich meadow on sandy soil.

The ordination diagram obtained using nonmetric multidimensional scaling (NMDS) calculated along the first two axes (Fig. 4), showed a distinct grouping along both axes. The distribution of the grasslands along the first axis (NMDS 1) was related to the soil pH. Along this axis, it was possible to notice an increase in species typical of very acidic soils, such as *Carex pilulifera*, *Vaccinium myrtillus* and *Calluna vulgaris*. The distribution of the clusters along the second axis (NMDS 2) may represent a gradient of soil humidity with steppic species, like *Artemisia campestris* and *Chrysopogon gryllus*, and species typical of fresh to moderately moist soils, like *Narcissus x verbanensis*, *Phleum rhaeticum* or *Stellaria graminea*.

Description of the identified plant communities

POO BULBOSAE-FESTUCETUM TRACHYPHYLLAE Lonati and Lonati 2007 (Tab. 1)

Characteristic and differential species: *Koeleria macrantha*, *Rumex acetosella*.

High frequency Taxa: *Artemisia campestris*, *Carex caryophyllea*, *Euphorbia cyparissias*, *Koeleria macrantha*, *Lotus corniculatus*, *Peucedanum oreoselinum*, *Plantago lanceolata*, *Ranunculus bulbosus*, *Rumex acetosella*, *Thymus pulegioides*.

Species composition: This community was dominated by *Koeleria macrantha* (Φ 0.88; *p*-value<0.001) and *Peucedanum oreoselinum* (Φ 0.45; *p*-value=0.07), accompanied by less demanding xerothermophytes, e.g. *Hieraci-*

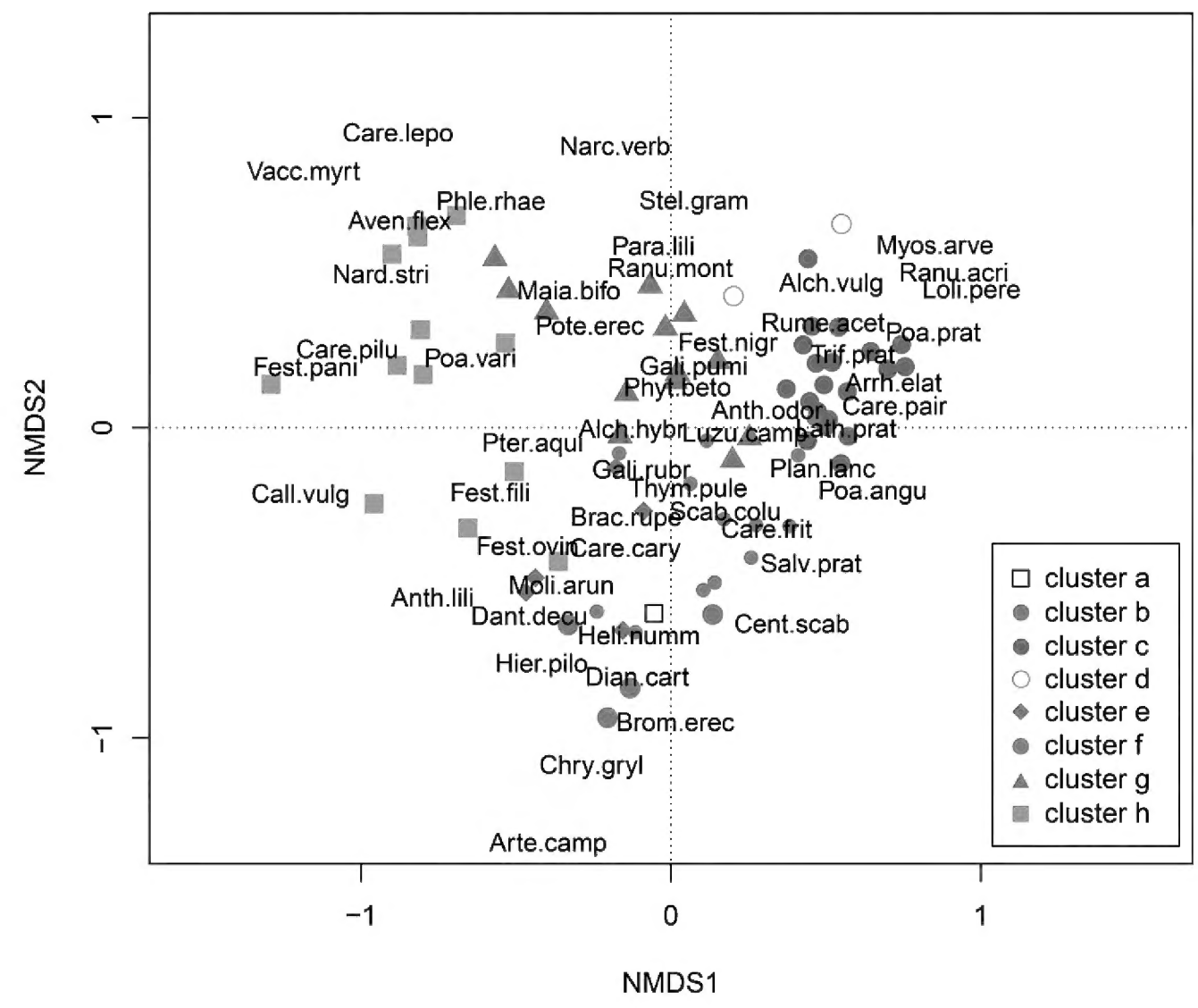

Figure 4. Ordination diagram of the total 71 relevés (NMDS). a: *Poo bulbosae-Festucetum trachyphyllae*; b: *Poo bulbosae-Festucetum trachyphyllae*, mesophilic variant c: *Centaureo transalpinae-Arrhenatheretum*; d: outlier; e: *Holco-Chrysopogonetum grylli*; f: *Phyteumo-Mesobrometum*; g: *Phyteumo betonicifolii-Festucetum nigrescentis*; h: *Carici piluliferae-Nardetum strictae* (for species abbreviations see Appendix IV).

Table 1. *Poo bulbosae-Festucetum trachyphyllae* Lonati et Lonati 2007 .

						Presence
Relevé number	72	42	8	7	66	
Altitude (m a.s.l.)	286	310	230	220	229	
Aspect	-	-	-	-	-	
Slope (degree)	0	0	0	0	0	
Relevé area (m^2)	25	25	25	25	25	
Species number	21	17	26	25	20	
Total coverage (%)	.	90	90	90	90	
Characteristic and differential species of *Poo bulbosae-Festucetum trachyphyllae*						
Koeleria macrantha (Lam.) P. Beauv.	+	3	1	1	2	5
Rumex acetosella L. s.l.	.	1	1	2	1	4
Characteristic species of *Stipo-Poion xerophilae* and *Festucetalia valesiaceae*						
Achillea collina	+	1	1	.	.	3
Festuca ovina aggr. (*Festuca trachyphylla* R. Tracey *pro maxima parte*)	2	1	.	.	.	2
Carex liparocarpos Gaudin	.	1	.	.	.	1
Pseudolysimachion spicatum (L.) Opiz	.	.	.	+	.	1
Characteristic species of *Festuco-Brometea* and subordinate units	.	.	.	.	.	
Artemisia campestris L. s.l.	+	2	.	r	+	4
Carex caryophyllea Latourr.	1	.	1	2	1	4
Euphorbia cyparissias L.	.	1	1	1	1	4
Lotus corniculatus L. s.l.	.	1	+	+	+	4
Ranunculus bulbosus L.	+	.	r	r	+	4
Thymus pulegioides L.	.	+	+	+	1	4
Bromus erectus Huds.	.	.	1	2	2	3
Dianthus carthusianorum L. s.l.	1	r	.	.	+	3
Helianthemum nummularium (L.) Mill.	+	.	+	1	.	3
Potentilla neumanniana Rchb.	1	+	.	1	.	3
Anthericum liliago L.	.	.	.	1	+	2
Centaurea splendens L.	.	.	.	+	+	2
Trifolium montanum L.	.	.	2	+	.	2
Centaurea scabiosa L.	.	.	+	.	.	1
Euphrasia stricta J. F. Lehm.	.	.	.	.	1	1
Galium verum L. s.l.	.	.	+	.	.	1
Luzula campestris (L.) DC.	.	.	2	.	.	1
Orchis morio L.	.	.	.	1	.	1
Orchis ustulata L.	.	.	.	r	.	1
Salvia pratensis L.	.	.	+	.	.	1
Thesium linophyllon L.	.	.	.	1	.	1
Hypochaeris maculata L.	.	.	.	+	.	1
Plantago media L.	+	.	.	.	.	1
Poa angustifolia L.	.	.	.	1	.	1
Companion species						
***Koelerio-Corynephoretea* and subordinate units**						
Jasione montana L.	+	+	.	.	+	3
Aira caryophyllea L.	2	+	.	.	.	2
Hypochaeris radicata L.	1	.	.	.	.	1
Sedum sexangulare L.	+	.	.	.	.	1
Trifolium arvense L.	.	.	.	.	+	1
***Molinio-Arrhenatheretea* and subordinate units**						
Plantago lanceolata L.	1	.	1	+	1	4
Agrostis capillaris L.	2	.	.	.	1	2
Anthoxanthum odoratum L.	+	.	1	.	.	2
Cerastium fontanum subsp. *vulgare* (Hartm.) Greuter & Burdet	.	.	1	r	.	2
Dactylis glomerata L.	.	.	1	.	.	1
Erigeron annuus (L.) Desf. s.l.	.	.	.	.	1	1
Festuca nigrescens Lam.	.	.	+	.	.	1
Knautia arvensis (L.) Coult.	+	.	.	.	.	1
Other species						
Peucedanum oreoselinum (L.) Moench	1	+	2	2	3	5
Chrysopogon gryllus (L.) Trin.	.	.	1	2	.	2
Hypericum perforatum L.	.	.	r	.	+	2
Calluna vulgaris (L.) Hull	.	.	.	r	.	1
Cytisus scoparius (L.) Link /S	+	.	.	.	.	1
Danthonia decumbens (L.) DC.	1	.	.	.	.	1
Echium vulgare L.	.	+	.	.	.	1
Festuca filiformis Pourr.	.	1	.	.	.	1
Hieracium pilosella aggr.	.	.	1	.	.	1
Hieracium piloselloides Vill.	.	+	.	.	.	1
Phyteuma betonicifolium Vill.	.	.	+	.	.	1
Thalictrum minus L.	.	.	+	.	.	1

um pilosella, *Galium verum*, *Thymus pulegioides*, *Carex caryophyllea*, *Potentilla neumanniana* and H*elianthemum nummularium*. Among the other species, *Rumex acetosella* (Φ 0.40; *p*-value=0.02) and *Euphorbia cyparissias* (Φ 0.90; *p*-value<0.001) showed significant values for the ISA. Pioneer grassland on sand species, like *Jasione montana*, *Trifolium arvense* or *Aira caryophyllea*, and mesic meadows species, like *Achillea millefolium* aggr, *Plantago lanceolata* were present. The clustering split the community into two groups. One relevé (number 71) had a higher cover of *Festuca trachyphylla*, *Aira caryophyllea*, *Hypochaeris radicata* and typical dry grassland on sandy soil species. The others (42, 8, 7, 66) were in different secondary transitional stages dominated by semi-dry grassland species, like *Bromus erectus*, *Lotus corniculatus*, *Trifolium montanum* and the presence of the protected species *Orchis ustulata* and *Orchis morio*. The number of species per relevé ranged between 21 and 25, with an average of 21.8.

Geographic distribution: These grasslands were found along the Maggia and the Melezza river. This community can be found in the entire Insubria region from Torino to Brescia (Studer-Ehrensberger 1993).

Synecology: The pH ranged between 4.5 and 5.0. The mean weighted Landolt indicator values were as follows: temperature (T) 3.58, continentality (K) 3.13, light (L) 3.85, moisture (F) 1.68, soil reaction (R) 2.90 and nutrients (N) 2.13, Humus (H) 2.89 (Fig. 5). The community is present on silicious stabilized sandy soil. That is no longer flooded along river terraces, representing a secondary successional stage maintained by agricultural practices The altitude in the hillzone ranged from 220 m a.s.l. to 310 m a.s.l. The surfaces were either mowed or extensively grazed by sheep. Each plot was on a site listed in the national inventory of dry meadows and pastures.

Syntaxonomical discussion: This plant community is included to the *Stipo-Poion xerophilae* alliance by the occurrence of *Achillea collina, Festuca trachyphylla* and *Carex liparocarpos*. This plant community was initially described in Insubria by Studer-Ehrensberger (1993) as the "*Jasione montana-Koeleria macrantha* community" within the *Koelerio-Phleion* alliance. She hypothesized that its presence was linked to the Insubrian climate. Lonati & Lonati (2007) identified *Poo bulbosae-Festucetum trachyphyllae*, which belongs to the *Stipo-Poion carniolicae* alliance, also confined to the Insubrian region with a pronounced

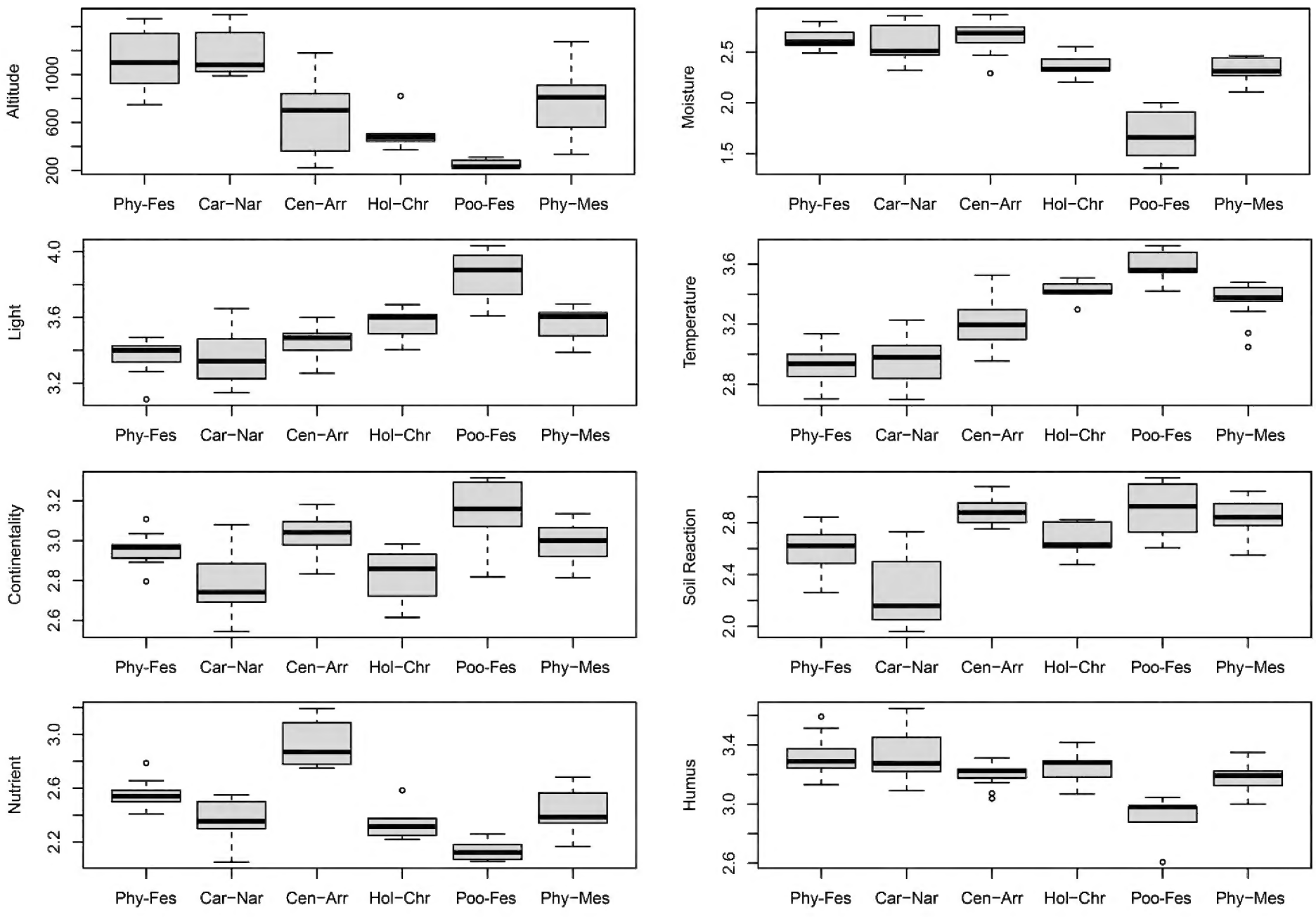

Figure 5. Boxplots showing the variability of altitude and other environmental indicators (i.e. Landolt's moisture, light, temperature, continentality, soil reaction, nutrients, humus) for each plant community. The abbreviations used are referred to the following plant association: Phy-Fes for *Phyteumo-Festucetum*, Car-Nar for *Carici-Nardetum*, Cen-Arr for *Centaureo-Arrhenatheretum*, Hol-Chr for *Holco-Chrysopogonetum*, Poo-Fes for *Poo-Festucetum* and Phy-Mes for *Phyteumo-Mesobrometum*.

subatlantic climate. Although Lonati & Lonati (2007) did not reference Studer-Ehrensberger's work, a comparison of the species lists and relevé locations suggests that the *Jasione montana-Koeleria macrantha* community is synonymous with *Poo-bulbosae-Festucetum trachyphyllae*. Both combined a high number of species characteristic of *Festuco-Brometea* with species principally occurring in the *Koelerio-Corynephoretea* class. Similar meso-xeric grasslands had previously been classified as the *Jasiono montanae-Festucetum ovinae* association in the *Hyperico perforati-Scleranthion perennis* alliance (Becker et al. 2012) within the *Koelerio-Corynephoretea canescentis* class. According to Chytrý (2010), all three alliances share diagnostic and constant species, such as *Festuca ovina* aggr. (cfr. *F. trachyphylla*), *Hieracium pilosella*, *Jasione montana*, *Rumex acetosella*, *Thymus pulegioides*, and *Hypericum perforatum*, all of which are found in our relevés. The high percentage of semi-dry meadow grasses (*Koeleria macrantha*, *Bromus erectus*, *Carex caryophyllea*) in these relevés brings them closer to the *Festuco-Brometea* class.

The species in Plot 71 of the inventory of dry grasslands are very similar to *Poo-bulbosae-Festucetum trachyphyllae*. However, the data does not specify which species of *Festuca ovina* aggr. is present. *Festuca trachyphylla* could only be confirmed in our own relevé 42. Relevés 8, 7, and 66 have a much higher proportion of mesophilic species, which could potentially represent a degradational stage due to pasture and are considered as a mesophilic variant without *Festuca trachyphylla*.

HOLCO-CHRYSOPOGONETUM GRYLLI Lagnaz, Trotta, Prunier, Krüsi et Boscutti 2023 ex Meyer 1976 (Tab. 2)

Lectotypus: Tab. 1, relevé 75 in Meyer (1976)

According to the International Code of Phytosociology (Theurillat et al. 2021), the name published by Meyer (1976) is not valid as it is a provisional name (Art. 3b). Therefore, we propose to validate the original name (Art. 6).

Characteristic and differential species: *Brachypodium rupestre*, *Chrysopogon gryllus*, *Danthonia decumbens*

High frequency Taxa: *Achillea millefolium* aggr., *Anthericum liliago*, *Anthoxantum odoratum*, *Brachypodium rupestre*, *Carex caryophyllea*, *Carex pilulifera*, *Festuca filiformis*, *Lotus corniculatus*, *Silene nutans*, *Thymus pulegoides*.

Species composition: This community was characterised by the dominance of *Chrysopogon gryllus* (Φ 0.3; p-value<0.05) and *Anthoxantum odoratum*. One relevé showed dominance of *Chrysopogon gryllus* combined with *Bromus erectus*. Other species with a significant fidelity according to ISA analysis were *Danthonia decumbens* (Φ 0.74; p-value<0.001) and *Brachypodium rupestre* (Φ 0.37; p-value<0.05). The protected species, *Serapias vomeracea*, was found in one relevé. Mesophilous meadow species, like *Plantago lanceolata*, *Centaurea transalpina* and *Rumex acetosa* were combined with typical semi-dry meadow species, such *Bromus erectus*, *Carex caryophyllea*, and *Silene nutans*. The latter had a higher frequency. The number of species per relevé ranged between 28 and 35, with an average of 30.2. One relevé (54) was an outlier with a dominance of Molinia arundinacea and other fringe vegetation species.

Geographic distribution: These grasslands are present in the Terre di Pedemonte and the outer part of Centovalli.

Synecology: They are present on exposed southern slopes (max. 30 degrees) in the hill belt of the Terre di Pedemonte and the outer area of Centovalli. In the Terre die Pedemonte, the altitude for this plant community ranged between 373 m a.s.l. and 507 m a.s.l. One relevé was located in Centovalli at 820 m a.s.l. and the pH was near 4.5. The Landolt indicator values were as follows: temperature (T) 3.41, continentality (K) 2.82, light (L) 3.55, moisture (F) 2.37, soil reaction (R) 2.66 and nutrients (N) 2.34 (Fig. 5). The surfaces were a combination of mowed and extensive pastures.

Syntaxonomical discussion: The association belongs to the alliance *Bromion erecti* by the occurrence of the characteristics species *Thymus pulegoides*, *Silene nutans*, *Luzula campestris*, *Ranunculus bulbosus*. In Switzerland, plant communities with *Chrysopogon gryllus* are limited to the Canton of Ticino. *Chrysopogon gryllus* has a wide amplitude and can be found also in different xerophytic communities in the central Alps extending to the Balkans, where its sociologic optimum occurs in the associations of the East continental order *Festucetalia valesiacae* (Ilijanić & Topić, 1989; Redzic, 1999). *Chrysopogon gryllus* grasslands in Ticino were first described by Koch (1943), as *Andropogonetum grylli insubricum*. It included siliceous and basophilous variants. The author defined *Festuca filiformis, Carex pilulifera, Agrostis capillaris* as differential species for the two variants. Meyer (1976) referred the two variants to *Carici humilis-Chrysopogonetum grylli* (basophilous) and *Holco-Chrysopogonetum grylli* prov. (acidophilous). Studer-Ehrensberger (1993) includes *Holco-Chrysopogonetum grilli* prov. in a new association, *Phyteumo-Mesobrometum*, within *Bromion* alliance. This attribution can be discussed. The P*hyteumo-Mesobrometum* association is characterized by a higher number of species in mown meadows, such as *Arrhenatherum elatius, Trisetum flavescens, Cerastium fontanum*. Furthermore, the dominance of *Chrysopogon gryllus* along with *Danthonia decumbens* and their absence in the *Phyteumo-Mesobrometum* grasslands validate the association described by Meyer (1976) Korneck (1978) placed semi-dry meadows on siliceous soils in the *Mesobromion* alliance. Recent phytosociological references agree that the *Mesobormion* alliance is limited to calcareous soil while dry meadows on siliceous soil should be placed in the *Koelerio-Phleion* alliance (Chytrý 2010; Biondi et al. 2014; Mucina et al. 2016). In the Locarnese region, typical species of *Koelerion-Phleion* are missing. Therefore, we propose to classify this association within the *Bromion* alliance. The occurrence of many mesophilous species like *Brachypodium rupestre, Holcus lanatus, Lotus corniculatus* and *Anthoxantum odoratum* are probably due to a legacy of traditional agricultural practices. The reference natural guide of habitats in Switzerland (Delarze et al., 2015) is limited to *Brachypodium pinnatum* and did not consider *Brachypo-*

Table 2. *Holco-Chrysopogonetum grylli* Lagnaz, Trotta, Prunier, Krüsi et Boscutti ex Meyer 1976 .

Relevé number	54	65	13	6	14	
Altitude (m a.s.l)	820	445	373	478	507	
Aspect	S	S	S	SO	S	
Slope (degree)	40	25	30	30	20	
Relevé area (m^2)	25	25	25	25	25	
Species number	28	28	35	30	30	
Total coverage (%)	90	90	100	100	100	Presence
Characteristic and differential species of *Holco-Chrysopogonetum grylli*						
Danthonia decumbens (L.) DC.	1	2	1	2	1	5
Brachypodium rupestre (Host) Roem. & Schult.	+	1	1	2	1	5
Chrysopogon gryllus (L.) Trin.	.	2	1	2	3	4
Bromion erecti* and *Brachypodietalia pinnati						
Thymus pulegioides L.	+	1	1	2	2	5
Carex caryophyllea Latourr.	1	1	.	1	1	4
Silene nutans L.	r	+	r	.	+	4
Lotus corniculatus L.	.	+	1	1	1	4
Bromus erectus Huds.	.	1	1	.	3	3
Helianthemum nummularium (L.) Mill.	+	.	+	.	1	3
Polygala vulgaris L. s.l.	.	+	+	.	1	3
Luzula campestris (L.) DC.	.	.	.	1	1	2
Ranunculus bulbosus L.	.	+	.	+	.	2
Characteristic species of *Festuco-Brometea*						
Anthericum liliago L.	+	r	+	.	+	4
Briza media L.	+	+	.	+	.	3
Characteristic species *Molinio-Arrhenatheretea* and subordinate units						
Anthoxanthum odoratum L.	1	+	3	3	1	5
Agrostis capillaris L.	.	1	1	.	+	3
Festuca nigrescens Lam.	.	.	+	1	+	3
Holcus lanatus L.	.	.	2	1	+	3
Ajuga reptans L.	.	.	+	1	.	2
Prunella vulgaris L.	.	.	+	+	.	2
Centaurea transalpina DC.	.	+	+	.	.	2
Plantago lanceolata L.	.	.	.	+	1	2
Rumex acetosa L.	.	.	.	+	1	2
Trifolium pratense L.	.	.	.	+	r	2
Characteristic species of *Nardetea strictae* and subordinate units						
Stachys officinalis (L.) Trevis.	.	+	+	1	+	4
Carex pilulifera L.	.	1	2	1	.	3
Carex pallescens L.	.	1	+	.	.	2
Other species						
Festuca filiformis Pourr.	2	1	2	2	2	5
Potentilla erecta (L.) Raeusch.	1	1	1	1	.	4
Cruciata glabra (L.) Ehrend.	.	.	+	1	+	3
Hypochaeris radicata L.	+	+	.	+	.	3
Molinia arundinacea Schrank	3	1	.	.	.	2
Carex fritschii Waisb.	2	.	1	.	.	2
Thalictrum minus L.	+	+	.	.	.	2
Clinopodium vulgare L.	.	.	+	.	+	2
Peucedanum oreoselinum (L.) Moench	+	+	.	.	.	2
Veronica officinalis L.	.	.	1	.	+	2
Pteridium aquilinum (L.) Kuhn	.	.	r	.	+	2
Solidago virgaurea L.	+	.	.	+	.	2
Vincetoxicum hirundinaria Medik.	r	.	.	.	+	2
Lathyrus linifolius (Reichard) Bässler	+	.	+	.	.	2

dium rupestre. Generally, the frequency and dominance of *Brachypodium pinnatum* in grasslands is linked to the intensification of pasture (Ellenberg and Leuschner 2010) or the abandonment of regular management, meaning *Brachypodium pinnatum* grasslands have been considered to be transitory vegetation stages (Häfelfinger, 1996; Bonanomi & Allegrezza, 2004). However, *Brachypodium rupestre* communities are well known where diverse associations have been described (Ubaldi 1988, Blasi et al. 2000, Di Pietro et al. 2015, Prunier et al. 2018). Based on works from Biondi et al. (2005), the *Polygalo mediterraneae-Bromion erecti* includes mesophilous non-calciphilous grasslands of the Apennines (Di Pietro et al. 2015). The

option of creating a new sub-alliance or alliance should be considered in any further study.

PHYTEUMO-MESOBROMETUM Studer-Ehrensberger 1993 (Tab. 3)

Characteristic and differential species: *Carex fritschii* (Φ 0.50; *p*-value<0.001), *Thymus pulegoides* (Φ 0.22; *p*-value<0.1), *Thalictrum minus* (Φ 0.30; *p*-value<0.05)

High frequency Taxa: L*uzula campestris, Achillea millefolium* aggr., *Brachypodium rupestre, Silene nutans, Anthoxantum odoratum, Festuca nigrescens, Ranunculus bulbosus*.

Species composition: All the diagnostic species showed a significant fidelity to this association (*Carex fritschii*, Φ 0.50, *p*-value<0.001; *Thymus pulegoides*, Φ 0.22, *p*-value<0.1; *Thalictrum minus*, Φ 0.30, *p*-value<0.05). Two variants could be distinguished: one variant (plots 22, 49, 50, 52) was drier than the second one (plots 11, 16, 17, 19, 33, 37, 53, 57, 59). The first one comprised three meadows of national importance. They contained *Festuca ovina* aggr. and a more abundant cover of species typical of dry grasslands, like *Helianthemum nummularium*, *Dianthus carthusianorum* and *Carex caryophyllea* and a presence of very dry indicators, like *Sedum annuum* and *Sedum telephium*. These plots were also characterized by the presence or dominance of species indicating short-term abandonment, like *Carex pairae, Vincetoxicum hirundinaria* or dominance of *Brachypodium rupestre*. The second variant was characterized by the presence of *Carex fritschii* with a cover abundance between 2 and 3 in all surveys. *Anthoxantum odoratum* was dominant and species typical of semi-dry meadows were also present, like *Centaurea scabiosa, Arabis hirsuta, Galium verum* and *Pimpinella saxifraga*. Species typically from *Arrhenatheretelia* like *Centaurea transalpina, Galium album, Poa pratensis* were present in the second variant and absent in the first one. *Bromus erectus* was present but never dominant. The protected species, *Lilium bulbiferum* and *Orchis ustulata*, were also found. The number of species per relevé ranged between 17 and 41, with an average of 31.6.

Geographic distribution: These grasslands had a wide amplitude and were spread throughout the study area.

Synecology: These grasslands were found on exposed southern and eastern slopes (from 10 to 45 degrees in gradient). The altitudes ranged from 334 m a.s.l. to 1274 m a.s.l. The pH ranged between 4.0 and 4.5. The Landolt indicator values were as followed: temperature (T) 3.35, continentality (K) 2.98, light (L) 3.56, moisture (F) 2.31, soil reaction (R) 2.85 and nutrients (N) 2.42, Humus (H) 3.18 (Fig. 5). Not all the areas seemed to have been mowed every year. A combination of mowing and grazing could also be noticed on the field. In some cases, this plant community can be found on old river terraces.

Syntaxonomical discussion: The association belongs to the alliance *Bromion erecti* by the occurrence of the characteristics species *Ranunculus bulbosus, Luzula campestris, Silene nutans*. Semi-dry grasslands on silicious soils in Ticino were described by Studer-Ehrensberger (1993) as *Phyteumo-Mesobrometum*. She distinguished two subassociations: *chrysopogonetosum grylli* and *achilletosum millefoli*. The subassociation *achilletosum millefoli* has many similarities with the relevés of the Locarnese, as they share many species (e.g. *Phyteuma betoncifolium, Bromus erectus, Thalictrum minus*). The main differences concern the cover of *Bromus erectus* and the presence of *Carex fritschii*. *Bromus erectus* is often dominant according to Studer-Ehrensberger and *Carex fristchii* is absent. Our relevés showed a presence of *Bromus erectus*, but this was never dominant, unlike *Carex fristschii*. We consider the relevés with a high cover of *Carex fritschii* as a locally variant associated with specific ecological and management attributes linked to elevation and mowing frequency.

CENTAUREO TRANSALPINAE-ARRHENATHERETUM Oberd. 1964 nom. mut. prop. Prunier et al. 2019 (Tab. 4)

Original name: *Centaurea dubiae-Arrhenatheretum elatioris* Oberdorfer 1964, art. 43

Synonyms: *Centaureo carniolicae-Arrhenatheretum elatioris* Oberdorfer 1964 corr. Poldini et Oriolo 1994, *Arrhenatheretum elatioris* Pedrotti 1964 non Scherrer 1925, *Arrhenatheretum elatioris* Buffa et al. 1989 non Scherrer 1925

Lectotypus: Tab. 9, relevé 4 in Oberdorfer (1964) by Poldini and Oriolo (1994)

Characteristic and differential species: *Centaurea transalpina*.

High frequency Taxa: *Achillea millefolium* aggr., *Arrhenatherum elatius, Silene vulgaris, Festuca nigrescens, Dactylis glomerata, Plantago lanceolata, Anthoxantum odoratum, Trifolium pratense, Leontodon hispidus*.

Species composition: These grass-rich meadows were generally dominated by *Arrhenatherum elatius* (Φ 0.45; *p*-value=0.06) and *Anthoxanthum odoratum*. *Centaurea transalpina* was the only other species whit a significant ISA value (Φ 0.58; *p*-value<0.01). *Trisetum flavescens* was present in all plots above 650 m a.s.l. but was never dominant. One meadow (relevé 29) showed signs of extensive management, with a dominance of *Chaerophyllum villarsii* and *Thalictrum minus*. All plots were characterized by nutrient rich grassland species, like *Dactylis glomerata, Trifolium repens, Ranunculus friesianus. Agrostis capillaris* and *Viola tricolor* indicated soil acidity. The presence of species from the Southern part of the Alps was typical for this association, particularly *Centaurea transalpina* and *Achillea roseo-alba* (which was aggregated into *Achillea millefolium* in the present work). Two variants could be distinguished: the first one contained meadows (relevés 15, 21, 24, 25, 34, 35, 36) that were more intensively managed on flat areas or gentle slopes (10-20 degrees) and was found below 700 m. The number of species was lower (average 24.7) than the second variant (relevés 2, 3, 9, 10, 12, 20, 23, 47, 48, 51, 58). The second variant had an average of 31.9 species. These were present on slopes up to 45 degrees. Some of them were found on formerly cultivated terraces. In one meadow, we found the locally protected species, *Lilium bulbiferum* subsp. *croceum*.

Table 3. *Phyteumo-Mesobrometum* Studer-Ehrensberger 1993 .

Relevé number	22	50	49	52	11	53	16	17	33	37	57	19	59	
Altitude m a.s.l.	811	1013	1069	911	403	849	555	560	334	603	782	840	1274	
Aspect	SE	S	S	SE	S	E	SE	SE	SE	E	SE	SO	SE	
Slope (degree)	30	10	50	30	30	30	20	30	20	20	45	45	30	
Relevé area (m^2)	25	25	25	25	25	25	25	25	25	25	25	25	25	
Species number	38	41	29	38	20	31	35	17	24	39	35	33	31	
Total coverage (%)	100	90	95	95	100	100	100	90	100	100	100	100	100	Presence
Characteristic and differential species of *Phyteumo-Mesobrometum*														
Thymus pulegioides L.	2	2	1	1	+	1	2	2	1	1	3	2	1	13
Thalictrum minus L.	1	+	1	+	.	+	1	1	1	+	1	r	1	12
Carex fritschii Waisb.	.	.	2	2	3	3	3	2	3	3	2	3	3	11
Characteristic species of *Bromion erecti* and *Brachypodietalia pinnati*														
Luzula campestris (L.) DC.	1	2	+	1	1	.	2	2	2	2	.	1	1	11
Silene nutans L.	.	+	.	+	.	+	r	+	+	1	1	+	1	10
Ranunculus bulbosus L.	2	+	.	+	2	+	+	.	.	1	1	+	.	9
Carex caryophyllea Latourr.	2	+	1	1	.	1	2	1	.	.	.	.	.	7
Lotus corniculatus L.	.	+	.	+	.	.	+	.	.	+	+	1	+	7
Helianthemum nummularium (L.) Mill.	2	2	.	1	.	.	.	.	.	1	2	2	2	7
Bromus erectus Huds.	.	.	.	1	.	.	+	+	.	2	2	.	.	5
Helictotrichon pubescens (Huds.) Pilg.	.	.	+	.	.	+	.	.	.	.	+	.	.	3
Poa angustifolia L.	.	.	1	.	2	.	+	.	.	.	.	.	.	3
Characteristic species of *Festuco-Brometea* and subordinate units														
Achillea collina (Becker ex Wirtg.) Heimerl	1	+	r	+	1	+	1	.	.	+	1	1	+	11
Brachypodium rupestre (Host) Roem. & Schult.	+	2	3	2	.	.	+	.	1	1	1	+	1	10
Briza media L.	+	+	.	+	.	.	.	+	.	+	.	1	2	7
Salvia pratensis L.	.	1	.	.	r	.	1	+	r	+	+	.	.	7
Dianthus carthusianorum L. s.l.	2	.	.	1	.	.	.	1	.	.	+	r	+	6
Festuca ovina aggr.	.	+	1	1	.	+	.	.	.	.	.	.	+	5
Anthericum liliago L.	.	.	r	+	.	.	.	.	.	.	1	.	.	3
Hieracium piloselloides Vill.	r	.	.	+	.	.	.	.	.	+	.	.	.	3
Characteristic species of Molinio-Arrhenatheretea and subordinate units														
Anthoxanthum odoratum L.	+	1	.	.	.	1	2	1	2	3	1	2	2	10
Festuca nigrescens Lam.	2	2	1	3	1	.	1	.	2	2	+	.	1	10
Leontodon hispidus L.	+	+	.	.	.	1	+	.	1	+	1	r	1	9
Viola tricolor L.	1	.	.	+	+	2	+	1	.	+	+	.	+	9
Arrhenatherum elatius (L.) J. & C. Presl	r	1	+	.	2	+	.	.	+	1	.	1	.	8
Plantago lanceolata L.	1	+	.	.	.	.	+	r	.	+	+	+	1	8
Cerastium fontanum subsp. *vulgare* (Hartm.) Greuter & Burdet	1	.	.	.	r	+	.	.	+	.	+	+	+	7
Rumex acetosa L.	1	.	.	.	.	1	1	+	.	+	+	1	.	7
Agrostis capillaris L.	.	+	.	.	+	1	.	.	.	+	1	.	1	6
Holcus lanatus L.	.	1	.	.	.	.	+	.	1	+	+	1	.	6
Dactylis glomerata L.	.	+	+	.	.	.	.	.	.	r	+	.	+	5
Trifolium pratense L.	+	.	.	.	r	.	.	.	.	r	+	1	.	5
Trisetum flavescens (L.) P. Beauv.	+	+	.	.	.	+	.	.	.	.	.	2	+	5
Lathyrus pratensis L.	.	+	r	.	.	.	.	.	.	.	+	+	.	4
Silene vulgaris (Moench) Garcke	.	+	.	.	.	.	.	r	.	+	.	.	+	4
Veronica chamaedrys L.	+	+	.	.	.	.	.	.	+	+	.	.	.	4
Trifolium repens L.	+	1	+	.	.	.	.	.	.	.	.	.	.	3
Leucanthemum vulgare aggr.	.	.	.	.	.	+	.	.	1	+	.	.	.	3
Other species														
Phyteuma betonicifolium Vill.	.	1	+	+	.	+	+	.	.	1	+	+	.	8
Clinopodium vulgare L.	.	.	+	+	r	.	1	.	.	.	.	+	1	6
Festuca filiformis Pourr.	2	.	.	.	.	2	1	2	.	.	1	1	.	6
Galium rubrum L.	.	1	+	.	.	.	+	.	.	.	+	1	+	6
Peucedanum oreoselinum (L.) Moench	r	.	.	+	.	.	.	.	1	1	.	r	.	5
Rumex acetosella L. *s.l.*	.	+	r	.	+	+	.	.	1	.	.	.	.	5
Cruciata glabra (L.) Ehrend.	1	.	.	.	.	.	1	.	2	1	.	.	.	4
Vincetoxicum hirundinaria Medik.	.	.	2	+	.	.	.	.	.	.	.	r	1	4
Avenella flexuosa (L.) Drejer	r	+	.	.	.	1	.	.	.	.	.	.	.	3
Carex pairae F. W. Schultz	+	+	1	.	.	.	.	.	.	.	.	.	.	3
Chrysopogon gryllus (L.) Trin.	.	.	.	1	.	.	1	2	.	.	.	.	.	3
Hypericum perforatum L.	.	+	.	+	.	+	.	.	.	.	.	.	.	3
Nardus stricta L.	.	+	.	+	.	+	.	.	.	.	.	.	.	3
Poa variegata Lam.	.	+	.	+	.	1	.	.	.	.	.	.	.	3
Potentilla erecta (L.) Raeusch.	.	.	.	+	.	+	.	.	.	.	+	.	.	3
Scabiosa lucida Vill.	.	+	.	.	.	+	.	.	.	.	.	.	+	3
Silene viscaria (L.) Borkh.	1	.	.	.	.	r	.	.	.	r	.	.	.	3
Vicia sativa subsp. *nigra* (L.) Ehrh.	+	.	.	.	.	.	+	.	.	.	.	+	.	3

Table 4. *Centaureo transalpinae-Arrhenatheretum* Oberd. 1964 nom. mut. prop. Prunier et al. (2019) .

Relevé number	29	30	24	35	34	36	15	21	25	48	10	20	9	23	12	51	2	3	47	58	
Altitude m a.s.l.	711	701	700	308	339	360	550	676	666	780	222	823	335	701	367	855	1160	1174	1057	1180	
Aspect	N	N	SE	SE	SE	E	O	S	N	SO	E	SO	NE	SE	NO	SE	E	E	SE	SE	
Slope (degree)	10	20	10	0	0	10	20	30	10	20	0	30	0	40	10	0	35	30	45	30	
Relevé area (m²)	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	
Species number	26	25	19	24	11	25	19	27	25	25	23	21	20	25	22	25	25	23	30	35	
Total coverage (%)	100	100	100	100	100	100	100	100	100	90	100	100	100	100	95	100	100	100	100	100	Presence
Characteristic and differential species of *Centaureo-Arrhenatheretum*																					
Centaurea transalpina (Schleich. ex DC.) Nyman	2	.	1	2	+	1	1	+	2	+	+	.	.	+	r	.	.	+	.	+	14
Characteristic species of *Arrhenatherion elatioris* and *Arrhenatheretalia elatioris*																					
Arrhenatherum elatius (L.) J. & C. Presl	+	2	.	+	+	1	.	3	+	3	2	2	3	3	1	1	2	2	1	1	18
Silene vulgaris (Moench) Garcke	.	+	+	1	1	1	.	.	1	+	2	.	1	r	1	+	1	+	1	1	16
Rumex acetosa L.	+	+	.	1	.	1	1	1	2	+	.	.	.	1	+	+	1	.	+	+	14
Trisetum flavescens (L.) P. Beauv.	1	+	1	.	.	.	.	2	2	1	1	2	.	1	.	+	+	2	1	+	14
Cerastium fontanum subsp. *vulgare* (Hartm.) Greuter & Burdet	.	.	+	1	.	+	1	.	1	.	2	1	.	.	.	+	1	1	+	+	12
Holcus lanatus L.	.	.	2	2	.	.	1	2	.	+	.	1	.	1	.	.	.	+	1	+	10
Galium album Mill.	1	1	1	.	.	.	.	1	+	.	.	.	+	+	.	+	.	.	+	.	9
Leucanthemum vulgare aggr.	r	.	.	2	.	.	.	1	1	1	.	.	.	.	.	.	1	+	.	+	8
Viola tricolor L.	.	.	.	1	.	+	.	.	.	.	+	.	1	.	.	+	2	.	1	1	8
Poa pratensis L.	.	.	.	1	2	2	.	.	.	.	.	.	.	.	+	+	.	.	.	+	6
Lolium perenne L.	.	.	.	1	1	+	+	.	.	.	.	.	.	.	.	.	+	.	.	+	6
Erigeron annuus (L.) Desf. *s.l.*	.	.	.	.	.	.	.	r	.	r	.	.	r	+	.	.	.	.	.	.	4
Characteristic species of *Molinio-Arrhenatheretea* and subordinate units																					
Achillea millefolium aggr.	1	1	1	2	2	2	2	2	1	+	1	1	+	1	+	+	+	1	+	1	20
Dactylis glomerata L.	+	r	2	+	+	1	+	1	r	+	2	+	2	2	+	.	1	2	1	+	19
Plantago lanceolata L.	1	+	2	2	2	+	1	1	+	+	1	+	2	1	1	2	2	.	+	1	19
Festuca nigrescens Lam.	+	1	2	.	.	1	2	2	2	1	2	2	1	2	2	2	1	2	1	2	18
Anthoxanthum odoratum L.	1	1	.	2	4	2	3	2	2	1	2	.	2	1	2	2	1	2	2	2	18
Trifolium pratense L.	1	1	2	1	.	+	2	2	2	1	.	1	1	2	r	+	+	1	1	+	18
Leontodon hispidus L.	2	2	+	2	2	1	+	1	2	+	.	r	1	.	.	+	.	.	+	1	15
Ranunculus acris L.	+	.	.	+	1	1	.	1	.	.	.	.	.	.	+	+	+	1	+	+	11
Trifolium repens L.	.	1	1	1	.	+	+	2	1	+	.	.	.	.	.	+	.	1	.	+	11
Agrostis capillaris L.	1	2	.	1	.	.	.	1	3	.	+	.	.	.	+	.	.	.	1	1	9
Chaerophyllum villarsii W. D. J. Koch	3	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	2	2	+	1	6
Lathyrus pratensis L.	.	.	.	.	.	.	.	1	.	+	.	+	.	1	+	+	.	.	.	.	6
Prunella vulgaris L.	.	.	.	.	.	.	.	+	1	.	.	.	.	+	.	.	+	+	.	.	5
Ranunculus friesianus Jord.	.	1	2	.	.	.	+	.	1	.	.	+	.	.	.	.	.	.	.	.	5
Pimpinella major (L.) Huds.	.	r	.	.	.	.	r	.	.	+	.	.	.	.	r	.	.	.	.	.	4
Characteristic species of *Festuco-Brometea* and subordinate units																					
Luzula campestris (L.) DC.	.	1	.	1	.	.	+	.	1	.	.	1	1	1	2	1	1	1	1	1	13
Thymus pulegioides L.	+	1	.	.	.	.	.	.	+	+	.	1	+	2	1	2	2	+	2	1	13
Veronica chamaedrys L.	.	.	.	.	.	+	2	1	1	.	.	+	+	+	1	+	+	.	+	.	11
Lotus corniculatus L. *s.l.*	2	.	+	.	.	.	.	+	.	+	+	.	.	.	.	.	.	1	+	1	8
Ranunculus bulbosus L.	.	1	.	.	.	.	.	.	.	1	+	1	.	.	1	1	.	.	r	1	8
Poa angustifolia L.	.	.	1	1	.	+	.	.	.	.	+	.	+	.	.	.	.	.	.	.	5
Briza media L.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	2	4
Carex caryophyllea Latourr.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	2	.	.	1	+	4

Table 4. Continuation.

Relevé number	29	30	24	35	34	36	15	21	25	48	10	20	9	23	12	51	2	3	47	58	
Altitude m a.s.l.	711	701	700	308	339	360	550	676	666	780	222	823	335	701	367	855	1160	1174	1057	1180	
Aspect	N	N	SE	SE	SE	E	O	S	N	SO	E	SO	NE	SE	NO	SE	E	E	SE	SE	
Slope (degree)	10	20	10	0	0	10	20	30	10	20	0	30	0	40	10	0	35	30	45	30	
Relevé area (m^2)	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	
Species number	26	25	19	24	11	25	19	27	25	25	23	21	20	25	22	25	25	23	30	35	
Total coverage (%)	100	100	100	100	100	100	100	100	100	90	100	100	100	100	95	100	100	100	100	100	Presence
Helictotrichon pubescens (Huds.) Pilg.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	1	.	+	4
Salvia pratensis L.	.	.	.	.	.	r	.	.	.	+	1	.	.	r	.	.	.	.	.	.	4
Other species																					
Phyteuma betonicifolium Vill.	+	1	.	.	.	.	.	+	.	.	.	+	.	1	+	+	2	2	2	+	11
Thalictrum minus L.	3	1	.	1	.	1	1	2	.	.	+	1	.	1	.	.	1	.	2	.	11
Carex pairae F. W. Schultz	.	.	+	+	.	r	.	+	.	.	+	+	1	1	.	.	.	.	.	+	9
Potentilla erecta (L.) Raeusch.	.	1	+	.	.	.	+	.	1	.	.	.	.	r	+	.	2	1	.	.	8
Carex fritschii Waisb.	1	.	1	.	.	+	.	1	.	.	+	3	.	.	+	.	.	.	.	.	7
Rumex acetosella L. s.l.	.	.	.	+	.	.	.	.	.	.	1	1	1	1	.	1	.	.	.	+	7
Peucedanum oreoselinum (L.) Moench	2	2	.	.	.	r	.	+	.	+	1	.	.	.	.	.	.	.	.	.	6
Carex pallescens L.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	5
Clinopodium vulgare L.	+	.	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	+	2	5
Myosotis arvensis Hill	.	.	.	.	.	+	.	.	1	.	+	.	+	.	.	.	.	.	.	+	5
Stellaria graminea L.	r	2	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	4

These grasslands were generally found above 700 m. They had a high frequency and cover of montane species like *Chaerophyllum villarsii* and *Phyteuma orbiculare*. They could be considered as a transitional stage to *Centaureo transalpinae-Trisetetum flavescentis*. The number of species per relevé ranged between 11 for the most intensively managed meadow to 35, with an average of 23.8.

Geographic distribution: This association is found South of the Alps in Ticino and Northern East Italy, from Comasco to Friuli (Poldini & Oriolo 1994; Studer-Ehrensberger 2000; Allegrezza & Biondi 2011) as in Slovenia (Velev 2018).

Synecology: The pH ranged between 4.5 and 5.0. This association had a wide amplitude. It was found across the whole study area in the hill and the lower montane zones at altitudes between 222 m a.s.l. and 1180 m a.s.l. The Landolt indicator values were as follows: temperature (T) 3.20, continentality (K) 3.02, light (L) 3.45, moisture (F) 2.66, soil reaction (R) 2.88 and nutrients (N) 2.92, Humus (H) 3.20 (Fig. 5). The areas were mowed. It was the only type of grassland in the study area used for hay production.

Syntaxonomical discussion: The association belongs to the alliance *Arrhenatherion elatioris* by the occurrence of the characteristic species *Arrhenatherum elatius, Silene vulgaris, Rumex acetosa, Galium album, Viola tricolor*, and *Poa pratensis*. Oberdorfer (1964) first described this association for the insubrian region. The phytosociological attribution of this community was due to the frequent occurrence of species only present in south side of the Alps, like *Achillea roseo-alba* and *Centaurea transalpina*. Poldini & Oriolo (1994) distinguished between the *Centaureo transalpinae-Arrhenatheretum* association in the *Arrhenatherion* alliance and a montane association called *Centaureo transalpinae-Trisetetum flavescentis* in the *Polygono-Trisetion* alliance, which corresponds to the *Trisetetum flavescentis insubricum* subassociation described by Marschall (1947) in the Leventina. As most of the diagnostic species, like *Geranium sylvaticum, Heracleum sphondyllium* and *Carum carvi* were absent and the *Arrhenatherion* species more frequent, this association could be excluded.

PHYTEUMO BETONICIFOLII-FESTUCETUM NIGRESCENTIS ass. nova (Tab. 5, Relevé 41 *holotypus*)

Characteristic and differential species: *Festuca nigrescens, Phyteuma betonicifolium, Crocus albiflorus, Phleum rhaeticum, Poa chaixii, Ranunculus montanus, Chaerophyllum villarsii.*

High frequency Taxa: *Achillea millefolium* aggr., *Agrostis capillaris, Rumex acetosella, Thymus pulegoides.*

Species composition: All diagnostic species showed a high fidelity to the association (*Festuca nigrescens* Φ 0.32, *p*-value<0.05; *Phyteuma betonicifolium* Φ 0.32, *p*-value<0.05; *Crocus albiflorus*, Φ 0.29, *p*-value<0.05; *Phleum rhaeticum*, Φ 0.40, *p*-value<0.05; *Poa chaixii*, Φ 0.4; *p*-value<0.05; *Ranunculus montanus*, Φ 0.49, *p*-value<0.05). These meadows were characterized by a mix of montane belt mesic meadow species (e.g. *Chaerophyllum villarsii, Phleum rhaeticum*), montane and subalpine belt mat-grass

dry pasture species (*Nardus stricta, Avenella flexuosa, Stellaria graminea*), and meso-xerophytic grassland species (e.g. *Thymus pulegoides, Silene nutans, Lotus corniculatus, Ranunculus bulbosus*). In many relevés *Festuca nigrescens* was dominant. Two variants were distinguished. In the first one (5, 18, 27, 28, 39, 41) *Festuca nigrescens* was always present and was dominant in half of the relevés. Two protected species were found in the first variant: *Lilium bulbiferum* and *Narcissus verbanensis*. In the second variant (43, 44, 46, 60, 61, 64, 68) there was a higher frequency of species typical of *Nardus stricta* grasslands, like *Nardus stricta, Carex pallescens, Alchemilla hybrida* aggr., *Galium rubrum, Poa chaixii*. The number of species per relevé ranged between 19 and 44, with an average of 30.5.

Geographic distribution: The first variant included four relevés from the Centovalli, one from the lakeside and one from the Onsernone Valley. The second variant included four relevés from the Onsernone valley and three from the Vergeletto valley.

Synecology: Grasslands belonging to the first variant were North facing and at altitudes ranging from 747 m a.s.l. to 1050 m a.s.l. The ones in the second variant were found in the upper mountain belt and were mostly South facing. The altitude ranged from 1100 to 1,465 m a.s.l. The pH ranged between 4.0 and 4.5. The Landolt indicator values were as follows: temperature (T) 2.92, continentality (K) 2.95, light (L) 3.36, moisture (F) 2.63, soil reaction (R) 2.59 and nutrients (N) 2.55, Humus (H) 3.31 (Fig. 5). The new association is consistent with other *Festuca rubra* and *Agrostis capillaris* meadows as traditional communities of hay meadows in central Europe (Studer-Ehrensberger 2000, Poschlod et al. 2009). They are linked to extensive management without or with very little fertilisation, on nutrient poor soils. In our relevés, some were only mowed, but most of them exhibit a combination of extensive grazing and mowing. One of them (relevé 44) seemed abandoned or at least was no longer maintained on a regular basis and had a high cover of V*incetoxicum hirundinaria*.

Syntaxonomical discussion: The association is included in the alliance *Nardo strictae-Agrostion tenuis* by the occurrence of the characteristic species A*venella flexuosa, Phyteuma betonicifolium, Carex pallescens, Poa variegata*. In Ticino, *Festuca rubra-Agrostis capillaris* meadows have been described by different authors (Pestalozzi 1990, Häfelfinger 1996, Studer-Ehrensberger 2000, Dietl in Klötzli et al. 2010). Dietl in Klötzli et al. (2010) and Studer-Ehrensberger (2000) agree that the classification of these grasslands is difficult because of their intermediate position between well-defined alliances (*Arrhenatherion, Polygono-Trisetion, Mesobromion, Nardus grasslands*), which leads to a lack of diagnostic species. The attribution of this plant community is complicated by the fact that there are several approaches to classifying alliances within the *Nardetalia* order. Some consider two separate alliances *Violion* and *Nardo-Agrostion* to be in the same order (Mucina et al. 1993, Chytrý 2010, Mucina et al. 2016). Others consider the two alliances to be in separate orders (Biondi et al. 2014), or none of them (Delarze et al. 2015). The ordination diagram (Fig. 4) confirms the intermediate position of these grasslands between the *Nardo-Agrostion* and the *Arrhenatherion*. However, the cluster analysis (Fig. 3), clearly positions these surveys in relation to the *Nardo-Agrostion* grasslands.

We could consider placing these grasslands in the *Violion* alliance (acidophilous nutrient poor grasslands), as our relevés have a lot of species in common with the *Polygalo-Nardetum* described in Friuli (Poldini & Oriolo, 1997). The fact that *Nardus stricta* should be dominant in this association (Poldini & Oriolo 1997; Chytrý 2010) and was not in our surveys, and the fact that Violion occurs mostly in lowland to submontane belts, led us to follow Mucina et al. (2016) and classify it within the *Nardo-Agrostion*.

CARICI PILULIFERAE-NARDETUM STRICTAE Marschall and Dietl 1974 (Tab. 6)

Synonyms: *Nardetum alpigenum* ss-ass. à *Carex pilulifera* et *Polygala serpyllifolia* Berset 1969, *Omalotheco sylvaticae-Nardetum strictae* Gillet in Ferrez et al. 2011

Characteristic and differential species: *Carex pilulifera, Nardus stricta*.

High frequency Taxa: *Carex pilulifera, Nardus stricta*.

Species composition: *Avenella flexuosa, Carex pilulifera* (Φ 0.55; *p*-value<0.1), *Festuca filiformis, Nardus stricta* (Φ 0.61; *p*-value<0.01) were the dominant species. Three variants could be distinguished: the first one (relevés 4, 62, 63) presented several semi-dry meadow species like *Festuca ovina* aggr., *Helianthemum nummularium, Thymus pulegoides* and *Silene nutans*. The second variant (relevés 1, 26, 32, 38, 40, 67, 70, 71) was very poor in species (mean 16), mostly dominated by *Carex pilulifera* or *Nardus stricta* (cover-abundance 4 or 5), the third characherized by dominance of *Festuca paniculata* (cover-abundance 3, resp. 4) and *Festuca filiformis*. The number of species per relevé ranged between 7 and 34, with an average of 17.1.

Geographic distribution: *Carici piluliferae-Nardetum strictae* was present throughout the whole studied area, except from the Vergeletto Valley. One relevé was from Pizzo Leone, five from the Onsernone Valley and five from Centovalli and two on the lakeside of Lago Maggiore.

Synecology: These grasslands were mostly on exposed southern slopes at altitudes between 989 to 1,498 m a.s.l. The slopes varied from flat to 40 degrees. With a mean of 26 species, the first variant had significantly more species than the second variant and third variant. Two of them belong to the federal inventory of dry meadows and pastures of national importance. The Landolt indicator values were as follows: temperature (T) 2.95, continentality (K) 2.78, light (L) 3.37, moisture (F) 2.57, soil reaction (R) 2.26, nutrients (N) 2.38 and Humus (H) 3.33 (Fig. 5).

Syntaxonomical discussion: The association is included in the alliance *Nardo strictae-Agrostion* by the high frequency and abundance of *Phyteuma betonicifolium, Festuca nigrescens*, and *Carex pallescens*. The *Nardus*-rich grasslands in Ticino are well known. Bär (1914) described

Table 5. *Phyteumo betonicifolii-Festucetum nigrescentis* ass. nova

Relevé number	27	28	39	41	5	18	68	64	46	43	44	60	61	
Altitude m a.s.l.	1050	899	978	927	924	747	1465	1342	1115	1261	1100	1406	1384	
Aspect	NE	N	E	NO	E	NO	S	S	S	S	S	E	S	
Slope (degree)	45	20	20	20	15	30	25	40	10	20	45	30	40	
Relevé area (m^2)	25	25	25	25	25	25	25	25	25	25	25	25	25	
Species number	22	22	25	29	44	36	19	37	24	33	34	31	40	
Total coverage (%)	100	100	100	100	100	100	90	100	100	100	100	100	100	Presence
Characteristic and differential *Phyteumo betonicifolii-Festucetum nigrescentis*														
Phyteuma betonicifolium Vill.	.	1	2	1	2	1	+	+	1	1	1	+	1	12
Festuca nigrescens Lam.	2	3	4	3	2	1	.	.	4	2	1	1	2	11
Poa chaixii Vill.	+	+	+	+	.	.	+	1	2	+	1	+	+	11
Chaerophyllum villarsii W. D. J. Koch	.	.	.	1	.	+	.	1	.	2	2	1	1	7
Ranunculus montanus aggr.	.	.	1	+	.	.	+	+	.	+	+	.	+	7
Crocus albiflorus Kit.	.	.	.	1	+	+	.	+	+	.	.	.	+	6
Phleum rhaeticum (Humphries) Rauschert	+	1	.	1	.	+	+	.	.	.	.	+	.	6
Characteristic species of *Nardo strictae-Agrostion* and *Nardetalia*														
Carex pallescens L.	.	.	+	.	2	1	+	1	+	1	1	.	+	9
Avenella flexuosa (L.) Drejer	2	4	.	.	.	2	1	.	.	.	.	.	1	5
Paradisea liliastrum (L.) Bertol.	.	r	.	+	.	r	.	+	.	.	.	.	r	5
Stellaria graminea L.	+	+	1	1	.	.	.	.	.	.	.	.	.	4
Carex pilulifera L.	2	2	.	.	.	.	.	.	.	.	.	2	1	4
Galium pumilum Murray	r	.	.	.	+	.	1	+	.	.	.	.	.	4
Poa variegata Lam.	.	.	.	.	+	.	2	.	.	.	.	2	1	4
Stachys officinalis (L.) Trevis.	r	.	.	.	1	.	.	+	.	.	.	.	.	3
Viola canina s.l.	1	.	.	.	+	.	.	.	.	.	1	.	.	3
Characteristic species of *Nardetea strictae* and subordinate units														
Nardus stricta L.	.	+	1	+	.	.	2	1	1	1	.	1	1	9
Alchemilla hybrida aggr. *sensu* K. Lauber	r	.	.	.	.	.	.	.	.	+	1	1	1	5
Characteristic species of *Molinio-Arrhenatheretea* and subordinate units														
Achillea millefolium aggr.	1	.	+	1	2	1	+	1	1	1	1	1	1	12
Agrostis capillaris L.	1	+	1	+	1	1	1	2	+	.	+	1	1	12
Veronica chamaedrys L.	1	.	+	+	+	.	.	+	+	+	1	.	+	9
Silene vulgaris (Moench) Garcke	.	.	+	+	1	.	+	.	+	1	+	+	1	9
Anthoxanthum odoratum L.	1	.	1	3	2	2	+	.	.	.	1	1	.	8
Dactylis glomerata L.	.	.	r	.	+	.	.	r	+	2	2	+	+	8
Trifolium pratense L.	.	.	.	r	1	1	.	+	.	+	+	+	+	8
Viola tricolor L.	.	.	+	.	+	.	.	.	1	+	+	1	.	6
Cerastium fontanum subsp. *vulgare* (Hartm.) Greuter & Burdet	.	.	.	.	+	.	.	.	+	+	+	.	+	5
Rumex acetosa L.	.	.	+	.	2	.	.	.	+	.	+	.	+	5
Trisetum flavescens (L.) P. Beauv.	.	+	+	.	.	.	+	.	.	.	+	.	2	5
Leontodon hispidus L.	.	.	.	.	1	.	.	.	.	+	+	2	.	4
Plantago lanceolata L.	.	.	.	.	.	.	.	.	.	+	+	+	.	3
Trifolium repens L.	.	.	.	.	1	+	.	+	.	.	.	.	.	3
Narcissus verbanensis (Herb.) M. Roem.	.	.	2	1	.	.	.	.	.	.	.	.	.	2
Characteristic species of *Festuco-Brometea* and subordinate units														
Thymus pulegioides L.	2	1	+	+	3	+	+	1	+	.	2	1	1	12
Luzula campestris (L.) DC.	+	1	+	1	2	2	.	1	.	.	.	+	1	9
Briza media L.	.	.	.	.	+	.	.	+	1	+	2	2	1	7
Carex caryophyllea Latourr.	.	.	.	.	1	.	.	1	2	2	1	1	1	7
Brachypodium rupestre (Host) Roem. & Schult.	3	+	.	.	+	+	.	2	.	.	.	+	.	6
Silene nutans L.	r	.	r	.	2	1	.	.	.	r	.	1	.	6
Festuca ovina aggr.	.	r	.	.	.	.	1	1	.	+	+	r	.	6
Lotus corniculatus L. s.l.	.	.	.	.	+	1	.	+	.	+	+	.	.	5
Polygala vulgaris L. s.l.	r	.	.	.	2	.	+	+	.	.	.	.	.	4
Ranunculus bulbosus L.	.	.	.	.	1	.	.	.	.	.	.	+	1	3
Other species														
Rumex acetosella L. s.l.	.	r	+	+	+	+	.	+	+	1	+	+	+	11
Potentilla erecta (L.) Raeusch.	2	1	1	2	2	+	+	1	.	.	.	.	.	8
Festuca filiformis Pourr.	.	.	+	+	1	1	.	+	.	.	.	1	.	6
Galium rubrum L.	.	.	.	.	.	.	.	+	1	+	+	+	1	6
Vincetoxicum hirundinaria Medik.	.	.	.	r	.	.	+	+	r	r	2	.	.	6
Thalictrum minus L.	.	.	.	+	.	1	.	+	+	.	+	.	1	6
Veronica officinalis L.	+	+	.	.	1	1	.	.	.	+	.	.	.	5
Hypericum perforatum L.	.	.	.	+	.	.	.	.	1	1	+	.	.	4
Carex fritschii Waisb.	.	.	.	2	1	1	.	.	.	.	.	.	.	3
Solidago virgaurea L.	.	.	.	.	2	+	.	+	.	.	.	.	.	3
Arabis ciliata Clairv.	.	.	.	.	.	.	.	.	.	.	+	+	+	3
Rosa spec.	.	.	.	.	.	.	.	r	.	.	.	+	r	3

Table 6. *Carici piluliferae-Nardetum strictae* Marschall and Dietl 1974 .

Relevé number	31	55	4	62	63	1	38	26	40	32	67	70	71	
Altitude m a.s.l.	1496	1013	-	1273	1243	1044	1012	1060	989	1498	1425	1101	1037	
Aspect	S	SO	-	S	SO	SE	SE	SE	NE	y	SO	N	S	
Slope	30	30	-	25	0	45	40	10	45	10	10	20	0	
Relevé area (m^2)	25	25	25	25	25	25	25	25	25	25	25	25	25	Presence
Species number	21	19	22	34	25	16	9	14	12	7	9	15	19	
Total coverage (%)	100	95	100	95	100	100	100	100	100	100	100	100	100	
Characteristic and differential species of *Carici piluliferae-Nardetum*														
Carex pilulifera L.	1	1	3	1	1	5	5	1	2	2	1	2	1	13
Nardus stricta L.	.	2	3	1	2	1	1	4	3	4	4	1	2	12
Characteristic species of *Nardo strictae-Agrostion* and *Nardetalia*														
Avenella flexuosa (L.) Drejer	1	.	.	.	.	.	+	+	2	3	2	2	1	8
Phyteuma betonicifolium Vill.	+	1	+	+	+	+	.	.	.	.	.	+	+	8
Festuca nigrescens Lam.	.	.	.	.	+	.	.	1	2	.	+	1	+	6
Carex pallescens L.	.	+	.	.	+	.	.	+	.	.	+	.	.	4
Poa variegata Lam.	2	2	.	.	.	.	.	.	.	.	.	.	.	2
Danthonia decumbens (L.) DC.	r	.	.	.	.	.	.	.	.	.	.	.	.	1
Cytisus scoparius (L.) Link /S	2	.	.	.	.	.	.	.	.	.	.	.	.	1
Characteristic species of *Nardetea strictae* and subordinate units														
Luzula campestris (L.) DC.	.	.	.	.	.	.	.	r	+	.	.	1	.	3
Characteristic species of *Juncetea trifidii* and subordinate units														
Festuca paniculata (L.) Schinz & Thell.	4	3	.	.	.	.	.	.	.	.	.	.	.	2
Hieracium lactucella Wallr.	+	.	.	.	.	.	.	.	.	.	.	.	.	1
Characteristic species of *Festuco-Brometea* and subordinate units														
Anthericum liliago L.	.	.	+	.	.	+	+	.	.	.	.	+	+	5
Thymus pulegioides L.	.	1	1	2	2	.	.	.	.	.	.	.	+	5
Carex caryophyllea Latourr.	2	.	.	1	2	.	.	.	.	.	.	1	.	4
Festuca ovina aggr.	1	.	2	2	2	.	.	.	.	.	.	.	.	4
Helianthemum nummularium (L.) Mill.	.	.	1	2	+	+	.	.	.	.	.	.	.	4
Silene nutans L.	.	1	1	+	+	.	.	.	.	.	.	.	.	4
Brachypodium rupestre (Host) Roem. & Schult.	.	.	.	1	1	1	.	.	.	.	.	.	.	3
Briza media L.	.	.	1	+	.	+	.	.	.	.	.	.	.	3
Lotus corniculatus L. s.l.	.	.	.	+	+	.	.	.	.	.	+	.	.	3
Ranunculus bulbosus L.	.	.	.	1	.	+	.	.	.	.	.	1	.	3
Veronica chamaedrys L.	.	+	.	.	.	.	.	.	.	.	.	.	.	1
Characteristic species of *Molinio-Arrhenatheretea* and subordinate units														
Anthoxanthum odoratum L.	.	1	1	.	.	.	.	.	1	1	+	.	.	5
Leontodon hispidus L.	+	.	+	+	+	.	.	.	.	.	.	.	1	5
Rumex acetosa L.	.	+	.	.	.	1	.	+	+	.	.	.	+	5
Poa chaixii Vill.	.	.	.	.	+	+	.	.	+	.	.	.	+	4
Plantago lanceolata L.	.	.	+	+	+	.	.	.	.	.	.	.	.	3
Silene vulgaris (Moench) Garcke	.	+	.	.	.	.	.	.	.	.	.	.	.	1
Viola tricolor L.	.	1	.	.	.	.	.	.	.	.	.	.	.	1
Holcus lanatus L.	.	+	.	.	.	.	.	.	.	.	.	.	.	1
Rorippa stylosa (Pers.) Mansf. & Rothm.	+	.	.	.	.	.	.	.	.	.	.	.	.	1
Other species														
Festuca filiformis Pourr.	1	3	1	1	1	+	1	1	.	.	.	2	3	10
Potentilla erecta (L.) Raeusch.	+	+	.	.	.	.	+	+	1	r	.	+	+	8
Veronica officinalis L.	.	+	.	+	.	+	.	+	.	.	.	.	+	5
Calluna vulgaris (L.) Hull	1	.	.	.	.	.	.	.	.	.	.	.	.	1
Galium rubrum L.	1	.	.	.	.	.	.	.	.	.	.	.	.	1
Pteridium aquilinum (L.) Kuhn	1	.	.	.	.	.	.	.	.	.	.	.	.	1
Vaccinium myrtillus L.	1	.	.	.	.	.	.	.	.	.	.	.	.	1
Vaccinium vitis-idaea L.	r	.	.	.	.	.	.	.	.	.	.	.	.	1
Rubus fruticosus aggr. *sensu* Landolt /S	+	.	.	.	.	.	.	.	.	.	.	.	.	1

them as "*Nardus*-desert", in reference to the low number of species. In Europe, not much literature can be found about this association. Only the French prodrome and the swiss reference system retain it (de Foucault 2012; Prunier et al. 2019). Most of the descriptions are related to the Jura region (Gallandat et al. 1995; Vittoz 1998; Ferrez et al. 2011). The first variant (relevés 4, 62, 63) is clearly distinguished from the second (relevés 1, 26, 32, 38, 40, 67, 70, 71) by the presence of xero-termophilic species, such as *Festuca ovina* aggr. and *Thymus pulegoides*. An affiliation to the association *Thymo-Festucetum* was an option. However, the Indicator Species Analysis (ISA) did not showed statistically significant values. For this reason, these surveys were not separated from the other *Nardus* grasslands.

Conclusions

This study has contributed to providing new phytosociological knowledge for a region that has been poorly studied. We found six associations distributed in four alliances and three classes (Tab. 7). It has confirmed the existence of secondary grasslands in riverbeds, *Poo bulbosae-Festucetum trachyphyllae*. It has also confirmed the presence of two of semi-dry grasslands on siliceous soils, *Holco-Chrysopogonetum grylli*, which has been, until now, provisional association and *Phyteumo-Mesobrometum*. This study has also contributed to a better understanding of the phytosociological attribution of nutrient-poor montane grasslands, with the description of the novel association *Phyteumo betonicifolii-Festucetum nigrescentis*, in the *Nardo-Agrostion* alliance. The most widespread plant community was the *Centaureo transalpinae-Arrhenatheretum* association, within the *Arrhenatherion* alliance. Unlike the northern Alps, where this alliance is replaced by Polygono-Trisetion at around 700 m a.s.l., it has been found up to 1,180 m a.s.l. on South-facing slopes. Also represented throughout the study area, *Carici piluliferae-Nardetum strictae* have been found on very acidic soils at altitudes ranging from 989 m a.s.l. to 1,425 m a.s.l.

A further consideration about dry grassland composition and conservation concerns the frequency and abundance of *Brachypodium rupestre*. This species resulted dominant in some stands across different investigated plant communities suggesting for its plausible encroachment behaviour, especially where a regular mowing or grazing is missing.

Since the number of surveys is low for some plant communities, future studies should also shed light on the attribution of grasslands with *Festuca paniculata* and confirm the presence of the *Thymo-Festucetum* association within the *Nardo-Agrostion* alliance.

Table 7. Synoptic table .

Class (FB: *Festuco-Brometea*, MA: *Molino-Arrhenatheretea*, NS: *Nardetea strictae*)	FB	FB	FB	MA	NS	NS
Association	PoFe	HoCh	ThCa	CeAr	PhFe	CaNa
Relevés numbers	5	5	13	20	13	13
Characteristic and differential species of *Poo bulbosae-Festucetum trachyphyllae* (PoFe)						
Koeleria pyramidata (Lam.) P. Beauv.	100	0	8	0	8	0
Rumex acetosella L. s.l.	80	40	54	35	38	38
Characteristic and differential species of *Holco-Chrysopogonetum grylli* (HoCh)						
Brachypodium rupestre (Host) Roem. & Schult.	0	100	77	15	46	23
Danthonia decumbens (L.) DC.	20	100	8	0	8	23
Chrysopogon gryllus (L.) Trin.	40	80	23	0	0	0
Characteristic and differential species of Phyteumo-Mesobrometum (PhMe)						
Thymus pulegioides L.	80	100	100	65	92	38
Thalictrum minus L.	20	40	92	55	46	15
Carex fritschii Waisb.	0	40	85	35	23	0
Characteristic and differential species of *Centaureo transalpinae-Arrhenatheretum* (CeAr)						
Centaurea transalpina (Schleich. ex DC.) Nyman	0	40	15	70	0	0
Characteristic and differential species of *Phyteumo betonicifolii-Festucetum nigrescentis* ass. nova (PhFe)						
Phyteuma betonicifolium Vill.	20	20	62	55	92	62
Festuca nigrescens Lam.	20	60	77	90	85	62
Poa chaixii Vill.	0	0	15	10	85	31
Ranunculus montanus aggr.	0	0	0	5	54	0
Chaerophyllum villarsii W. D. J. Koch	0	0	0	30	54	8
Crocus albiflorus Kit.	0	0	8	10	46	8
Phleum rhaeticum (Humphries) Rauschert	0	0	0	0	46	8
Characteristic and differential species of *Carici piluliferae-Nardetum* (CaNa)			0			
Carex pilulifera L.	0	60	8	5	31	100
Nardus stricta L.	0	0	23	0	69	92
***Festuco-Brometea* and affiliates**						
Carex caryophyllea Latourr.	80	80	54	20	54	31
Lotus corniculatus L. s.l.	80	80	54	40	38	23
Ranunculus bulbosus L.	80	40	77	40	23	23
Helianthemum nummularium (L.) Mill.	60	60	54	5	8	31
Bromus erectus Huds.	60	60	38	5	0	0
Silene nutans L.	0	80	77	15	46	31
Luzula campestris (L.) DC.	20	40	85	65	69	23
Anthericum liliago L.	40	80	23	0	8	38
Dianthus carthusianorum L. s.l.	60	20	46	5	8	15
Briza media L.	0	60	54	20	54	23
Festuca ovina aggr.	40	20	38	0	46	31
Salvia pratensis L.	20	0	54	20	0	0
Potentilla neumanniana Rchb.	60	0	0	0	0	0
Poa angustifolia L.	20	0	23	25	0	0
Trifolium montanum L.	40	0	0	5	0	0

Table 7. Continuation.

Class (FB: *Festuco-Brometea*, MA: *Molino-Arrhenatheretea*, NS: *Nardetea strictae*)	FB	FB	FB	MA	NS	NS
Association	PoFe	HoCh	ThCa	CeAr	PhFe	CaNa
Relevés numbers	5	5	13	20	13	13
Veronica chamaedrys L.	0	0	31	55	69	15
Viola canina s.l.	0	20	8	5	23	0
Helictotrichon pubescens (Huds.) Pilg.	0	0	23	20	0	0
Silene viscaria (L.) Borkh.	0	0	23	0	0	0
***Molinio-Arrhenatheretea* and affiliates**						
Achillea millefolium aggr.	60	80	85	100	92	8
Dactylis glomerata L.	20	0	38	95	62	0
Plantago lanceolata L.	80	40	62	95	23	23
Anthoxanthum odoratum L.	40	100	77	90	62	38
Silene vulgaris (Moench) Garcke	0	20	31	80	69	23
Leontodon hispidus L.	0	0	69	75	31	38
Rumex acetosa L.	0	20	38	70	85	0
Trisetum flavescens (L.) P. Beauv.	0	0	38	70	38	8
Cerastium fontanum subsp. *vulgare* (Hartm.) Greuter & Burdet	40	0	54	60	38	8
Trifolium repens L.	0	0	23	55	23	8
Ranunculus acris L.	0	0	0	55	0	0
Holcus lanatus L.	0	60	46	50	8	8
Agrostis capillaris L.	40	60	46	45	92	15
Viola tricolor L.	0	0	69	40	46	15
Leucanthemum vulgare aggr.	0	20	23	40	8	0
Lathyrus pratensis L.	0	0	31	30	8	0
Poa pratensis L.	0	0	15	30	8	0
Lolium perenne L.	0	0	0	30	0	0
Ranunculus friesianus Jord.	0	0	0	25	8	0
Prunella vulgaris L.	0	40	0	25	0	0
Hypochaeris radicata L.	20	60	15	15	8	15
Ajuga reptans L.	0	40	8	5	0	0
Rorippa stylosa (Pers.) Mansf. & Rothm.	0	0	0	5	0	8
***Nardetea strictae* and affiliates**						
Avenella flexuosa (L.) Drejer	0	20	23	5	38	62
Carex pallescens L.	0	40	8	25	69	31
Alchemilla hybrida aggr. *sensu* K. Lauber	0	0	8	0	38	15
Polygala vulgaris L. s.l.	0	60	8	10	31	15
Stachys officinalis (L.) Trevis.	0	80	15	5	23	15
Stellaria graminea L.	0	0	0	20	31	9
Galium pumilum Murray	0	0	15	10	31	0
Scabiosa lucida Vill.	0	20	23	15	15	8
Other species						
Peucedanum oreoselinum (L.) Moench	100	40	38	30	8	0
Festuca filiformis Pourr.	20	100	46	0	46	77
Potentilla erecta (L.) Raeusch.	0	80	23	40	62	62
Galium rubrum L.	0	20	46	5	46	23
Veronica officinalis L.	0	40	8	10	38	38
Vincetoxicum hirundinaria Medik.	0	40	31	0	46	15
Clinopodium vulgare L.	0	40	46	25	15	0
Pteridium aquilinum (L.) Kuhn	0	40	0	5	8	15
Cruciata glabra (L.) Ehrend.	0	60	31	10	8	0
Hypericum perforatum L.	40	0	23	5	31	8
Calluna vulgaris (L.) Hull	20	0	0	0	0	23
Hieracium pilosella aggr.	20	20	23	0	0	15
Rubus fruticosus aggr. *sensu* Landolt /S	0	20	0	0	0	15
Festuca paniculata (L.) Schinz & Thell.	0	20	0	0	0	23
Hieracium lactucella Wallr.	0	0	8	0	8	8
Vaccinium myrtillus L.	0	0	0	0	8	23
Cytisus scoparius (L.) Link	20	0	0	0	0	8
Molinia arundinacea Schrank	0	40	8	5	8	8
Carex pairae F. W. Schultz	0	0	23	45	0	0
Solidago virgaurea L.	0	40	0	5	23	0
Rosa spec.	0	20	15	0	23	0
Lathyrus linifolius (Reichard) Bässler	0	40	0	10	8	0
Vaccinium vitis-idaea L.	0	0	0	0	0	8
Arabis ciliata Clairv.	0	0	8	5	23	9
Aira caryophyllea L.	40	0	0	0	0	0
Myosotis arvensis Hill	0	0	8	25	0	0

Syntaxonomic scheme

FESTUCO VALESIACAE-BROMETEA ERECTI Br.-Bl. & Tüxen ex Br.-Bl. 1949
BRACHYPODIETALIA PINNATI Korneck 1974
Bromion erecti Koch 1926
Holco-Chrysopogonetum grylli Lagnaz, Trotta, Prunier, Krüsi et Boscutti 2023 ex Meyer 1976
Phyteumo-Mesobrometum Studer-Ehrensberger, 1993
FESTUCETALIA VALESIACEAE Br.-Bl. et Tüxen ex Br.-Bl. 1949
Stipo-Poion xerophilae Br.-Bl. & Richard 1949
Poo bulbosae-Festucetum trachyphyllae Lonati & Lonati, 2007

MOLINIO-ARRHENATHERETEA Tüxen 1937
ARRHENATHERETALIA ELATIORIS Tüxen 1931
Arrhenatherion elatioris Koch 1926
Centaureo transalpinae-Arrhenatheretum Oberd. 1964 nom. mut. prop. Prunier et. al 2019

NARDETEA STRICTAE Rivas Goday in Rivas Goday & Rivas-Martínez 1963
NARDETALIA Preising 1950
Nardo strictae-Agrostion tenuis Sillinger 1933
Phyteumo betonicifolii-Festucetum nigrescentis ass. nova
Carici piluliferae-Nardetum strictae Marschall and Dietl 1974

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